THE GLASS INDUSTRY

VOLUME 17, NUMBER 5, MAY, 1936

CERAMIC SOCIETY HOLDS ANNUAL MEETING

COLUMBUS DRAWS RECORD ATTENDANCE. FRANCIS FLINT ELECTED PRESIDENT. SUMMARY OF GLASS DIVISION PAPERS.

UNDISMAYED by the floods which lapped at the doors of many glass factories last month, scores of glass men and hundreds from the ceramic and allied industries made their annual pilgrimage to the meeting of the American Ceramic Society, which this year was held in Columbus, Ohio, March 29 to April 4. History will record the program as successful; on the whole, less interesting than many of its predecessors, but now and then flashing gems of real brilliance that will long be remembered.

In the Glass Division, the cry has always been for papers of a more truly scientific character. This year that objective was attained. The results demonstrated that only a small percentage of the audience was able to derive full benefit from a program of this character. By contrast, the moving pictures by Corning Glass Works, showing an analysis of annealing, was nothing less than an inspiration on the part of the Committee. Perhaps, nothing presented at any meeting has been received as well.

Professor W. J. McCaughey of Ohio State University, who was the Edward Orton, Jr., lecturer this year, placed this Tuesday night feature on a new high plane. In the classroom, Professor McCaughey ordinarily requires a minimum of five separate lectures to cover the ground which that evening he compressed into two hours. Notwithstanding this, he gave an admirably clear and comprehensive lecture. Also deserving high praise was the lecture on stained glass by Lawrence Saint, one of the world's foremost authorities.

The Society elected 33 new Fellows, thereby not only establishing a new record in point of members, but also giving belated recognition to several individuals whose attainments and service to both the industry and to the Society has been noteworthy.

No account of this meeting would be complete without mention of the large student representation. Although Ohio State led all the ceramic colleges in point of numbers by reason of its close proximity, it had to share honors with Alfred University, which brought 31 students all the way to Columbus from its comparatively remote campus.

Officers elected to serve the American Ceramic Society during 1936 and 1937 were: President, Francis C. Flint, chief chemist, Hazel-Atlas Glass Co., Zanesville, Ohio; Vice-President, Robert B. Sosman, Research Laboratory, United States Steel Corporation, Kearny, N. J.; Treasurer, H. B. Henderson, H. B. Henderson Co., New Brighton, Pa.; Past President, J. M. McKinley, North American Refractories Co., Cleveland, Ohio; Past President, W. Keith McAfee, Universal Sanitary Mfg. Co., New Castle, Pa.

The Glass Division elected J. S. Gregorius, Pittsburgh Plate Glass Co., Creighton, Pa., chairman, with A. N. Finn of the National Bureau of Standards, Washington, D. C., as vice-chairman. Dr. S. R. Scholes of the New York State College of Ceramics at Alfred, N. Y., will act as secretary.

By vote of the Executive Committee, the 1937 convention will be held in New York City.

Summaries of the various papers read at the Glass Division are given:

1. Otto Schott: A Tribute

by Dr. Alexander Silverman, Department of Chemistry, University of Pittsburgh, Pittsburgh, Pa.

2. Progress Report on the Determination of the Tensile Strength of Glass

by A. E. Badger and W. B. Silverman: Dept. of Ceramic Eng., University of Illinois, Urbana, Ill.

The tensile strength of any material, whether it be a ductile substance like some metals or a brittle substance like glass, is a relative value which depends chiefly on the following factors:

1. The size and shape of the test specimen;
2. The rate at which the load is applied;
3. The presence of flaws in the specimen and the condition of its surface;
4. Imperfections of the testing machine.

Working tensile values should be obtained from tests on commercial specimens. In the present work the relation between tensile strength and chemical composition was investigated.

A discussion of the above factors was followed by a description of a machine which was designed to break glass fibres of 0.027 inch diameter in pure tension. These small scale tests are useful in determining the tensile strengths of different glasses as functions of their chemical compositions.

Several types of glass were tested, including plate and bottle glass compositions, an enamel ground coat, and a lead barium glass. The measured tensile strength values were correlated with the appearance of the fractured sections of the fibres.

Additional data will be presented at a later date.

3. The Modulus of Elasticity of Glass: (a) The Effect of Thermal History; (b) Effect of Temperature Changes

by Guy E. Strong, Corning Glass Works Laboratories, Corning, N. Y.

The present investigation was undertaken to determine the probable effect that thermal history might have on the modulus of elasticity.

Preliminary work showed that the magnitude of the effect was only a small fraction of the modulus of elasticity value. Accordingly, special apparatus was constructed so as to insure the required accuracy. As the defections are small and the sample dimension difficult to measure by the usual fibre method it was decided to use a method employing rectangular beams, 2.5 mm thick, 10 mm wide and 12 cm long.

A complete description of the apparatus and method of use was given. In the discussion of sources of error, it was shown that the measurement of the sample thickness was the greatest source of error. All measurements of elasticity were given a 0.1 per cent correction for defection due to shear. Measurements made at elevated temperatures were corrected for expansion of the sample and the metal parts of the equipment.

The glass used in both the tests on the effect of thermal history and on the effect of temperature change was a Corning bulb glass having the following properties: softening point 696°C, annealing point 510°C, strain point 478°C. The samples were ground and polished to the following dimensions, 3mm x 12 mm x 15 cm, and given various heat treatments followed by annealing or stabilizing treatments. The samples were then ground and polished to the required dimensions. The heat treatments, stabilizing treatments and annealing curves used on the various samples were given in detail.

From the results of the various tests the author concluded as follows: the same heat treatment gives the same modulus; the change in modulus is of the same order of magnitude for heat treatments below the anneal point as for those above the annealing point; various annealing schedules give distinctly different values of modulus. The modulus of the glass investigated is influenced by the thermal history of the samples, the modulus being higher for samples given a lower heat treatment. The modulus showed a smooth decrease with decreasing temperature, the rate of decrease increasing rapidly as the temperature approached 450°C.

4. Experiences in Impact Tests of Super-Tough or Heat-Treated Glass

by E. L. Hettinger, Willson Products, Inc., Reading, Pa.

As it is impossible to determine in advance the dimensions, physical properties or the speed of the object that the glass lens in an eye-protecting goggle must resist, it has been necessary to develop a lens of maximum toughness for this use. The action of a flying piece of metal on impact with the lens is such that the glass must be Super-Toughened instead of just hard and brittle. The results of impact tests made by the author on such a glass was then described.

Static pressure tests were made on glass discs with a Carver press, a Baldwin-Southwork press and a Perkins press. The results, shown in Table I, were obtained by means of the Carver press operated as follows: a steel plunger ½" dia. descended on the center of a 50 mm lens supported on a steel block with a hollow center. The glass was supported by a ⅛" ledge.

By using various plunger speeds, the results obtained indicated that the true instantaneous strength of glass is infinite, as it was found that, after contact was made with the glass by the plunger, the application of quickened pressure strokes would double or triple the breaking point readings.

In the high velocity tests, steel and lead balls of various weights were forced through a pipe with air pressures varying from one to 10 lbs., striking the glass samples. This procedure more nearly duplicates actual usage and gives more illuminating results than falling body impact tests. Shadow pictures of the broken samples were projected on a screen and the various types of fractures obtained in the tests were illustrated and discussed.

TABLE I

Mn. Dia.	Mn. Thickness	Not treated lbs.	Super-Tough lbs.
45.8	3.48	148	469
47.5	3.48	98	435
50	3.48	88	361
52	3.48	75	336

These shadow pictures successfully contradicted the erroneous idea that Super-Toughened or heat-treated glass which is properly and severely chilled will break as soon as the surface is disturbed and indicate that the behavior of such glass is not quite as erratic as previous investigators have believed.

5. Strength and Physical Properties of Fine Glass Fibres and Yarns

by G. Slayter, Owens-Illinois Glass Co., Toledo.

Glass threads have been produced consisting of 60 filaments, each filament having a diameter of 0.00025" and a tensile strength of 250,000 lbs. per sq. in. The diameter of the strand is 0.0067" and it has a tensile strength of 17,350 lbs. per sq. in.

Among those inducted into fellowships of the American Ceramic Society are the following, left to right: R. E. Birch, R. A. Blunt, W. M. Clark, J. S. Gregorius, G. N. Jeppson, G. V. McCauley. At top of page 149, left to right, are: L. C. Roche, D. D. Schurtz, D. E. Sharp, F. J. Tone, James Vail, E. C. Van Schoick.

In practice the glass fibres are lubricated so as to prevent their scratching one another during weaving and other operations. The lubricant is then washed out of the finished article with soap and water. It was thought that this lubrication might contribute something to the strength of glass but tests on lubricated and non-lubricated fibres showed no difference. It was concluded that lubrication merely prevents scratching of the glass surface and thereby prevents the weakening of the fibre.

Samples of glass fibre, silk, cords and other articles woven from this material were exhibited.

Slides were shown which illustrated a new chainomatic device for determining the tensile strength of glass fibres; a comparison of the strengths of fibres determined by this method with published strengths of glass fibres taken from the literature; and a chart from which the surface per pound and the length per pound could be determined from the thickness of the fibre.

The strength of the fibre increases very rapidly as the fineness of the fibre goes below 0.0002". Fibres of 0.0005" dia. have a strength of 1½ million lbs. per sq. in. Manipulation of the fibre in the manufacturing process is the controlling factor in developing maximum strength, as chemical composition seems to have no effect within the range of glasses so far produced. With such material, chemical attack and surface disintegration are important factors in decreasing the strength of the fibres.

The use of the thickness chart showed that one lb. of glass fibre, 0.0002" in diameter, would have an area of 1,500 sq. ft. and a length of 23 million feet.

6. The Abrasion of Glasses as Related to Composition

by S. R. Scholes, Dept. of Glass Technology, New York State College of Ceramics, Alfred, N. Y.

The abradability or ease of grinding of glass is of direct interest to those engaged in grinding or polishing various types of glass ware. Abradability may also serve as a measure of the relative hardness of glasses.

The experimental method and the apparatus used in this investigation was described in detail. The method of grinding employed was the usual one used in plate glass manufacture in which wet sand is held against the glass by revolving steel discs. The apparatus was modified so that the results would be on a quantitative basis.

The glass specimens (commercial glasses and experimental melts) in the form of rods, 4 to 7.5 mm dia. and 10 cm long, with ground ends were weighed and placed in the grinding machine for a one hour period. After removal the samples were again weighed. Standard samples of Vitreosil were included in each run. After suitable corrections for load, diameter and specific gravity were applied, the average loss of the glass samples was divided by the loss for Vitreosil and the results designated as the Coefficient of Abradability (Vitreosil= 1.0). The accuracy of the work thus far did not justify the use of more than one decimal place in the expression of the results. These are given in Table I.

In the discussion of the results obtained, it was shown that silica is the most important component in the reduction of abradability. Substitution of lime for part of the soda in a sodium silicate glass seemed to have little effect on the reduction of abradability. The replacement of lime by boron reduces abradability while the addition of alumina seemed to have little effect. The relative hardness of commercial glasses was thought to be due to their complexity rather than to the effect of the hardness of the separate components. The work is not far enough advanced to allow factors to be derived for the effect of different glass forming oxides.

TABLE I

Material	Abradability
Vitreosil	1.0
Pyrex	1.6
Borosilicate	2.4
Container glasses	2.7-3.0
Lime glass	3.3
Soda-silica glass	3.4
Soda-lead glass	3.9
Soda-lead glass	4.2
Soda-borate glass	5.0

7. Solubility Characteristics of Glasses Basically Different in Composition

by W. C. Taylor and R. D. Smith, Corning Glass Works Laboratories, Corning, N. Y.

While previous results on durability method No. 1 indicated that it might be satisfactory as a standard procedure, it seemed advisable to secure data on glasses of compositions other than soda-lime-silica to see if the method would be of general or restricted application. Additional tests were therefore made on two borosilicate, two lime and two lead glasses, all of which showed satisfactory durability under their particular conditions of service.

In addition to using Method No. 1, as proposed, certain modifications were also made in order to study the effect of different reagents (n/50 H_2SO_4, n/50 NaOH, and Water) and the effect of temperature (25°, 40° and 90°C). In all tests the weight of glass used was adjusted so as to conform with equivalent areas when using glasses differing from 2.5 density. Fogging tests were also made on the various glasses and the results compared with the data obtained by use of the No. 1 method.

From the results obtained by the American Ceramic Society Method No. 1 on these six different commercial glasses, it was concluded that they do not give a correct indication of the general usefulness of a glass and in fact would be misleading, even if restricted to weathering or acid or alkaline solubility. Certain modifications of the method might be made which would give a better measure of the general usefulness of these glasses.

The work done so far merely indicates that it may be impossible to obtain any single test which will measure the general durability of glass, as different type glasses vary decidedly in durability according to the solvent used, the temperature and other conditions. It seems likely that it will be necessary to either specify tests for different types of glasses and usages or else test the glasses under more than one set of conditions.

The method, as is, is suitable only for the simple soda-lime-silica type of glass and further work is necessary before a more general method can be adopted.

8. The Area of Glass Particles as Used in Durability Tests

by J. E. Ferguson and Karl Lark-Horovitz, Department of Physics, Purdue University, Lafayette, Ind.

While this paper was not presented at the A. C. S. meeting, it is hoped that this data may be published in The GLASS INDUSTRY in the near future.

9. Some Preliminary Observations on Reactions between Glass and Phosphate Solutions

by A. S. Watts, Dept. of Ceramic Engineering, Ohio State University, and J. B. Brown, Physiological Chemistry Dept., Ohio State University.

Saline solutions containing phosphates and which approximate normal saliva, when kept in contact with a glass surface, will attack and etch the glass. It was found by comparing the activity of a fresh solution against a solution that had been in contact with glass for some time, that the former was the more active. Removal of carbon dioxide from the solution had no effect, while heating the solution at 80°C for several days in Pyrex reduced its corrosiveness. Heating the solution in contact with powdered glass also reduced its corrosiveness. The extent of corrosion was determined by examining the glass surface for dullness, and etching by means of a microscope.

Treatment of a fresh solution with nickel and quartz showed no inactivation, while treatments with glass in various forms such as bottles, flasks or powder, always inactivated the solution. The pH of the solution and the weight of glass exposed does not alter appreciably. Further study is necessary before conclusions regarding the mechanism of the inactivation process can be drawn.

10. Devitrification Rates as Governed by Viscosity

by Howard R. Lillie, Corning Glass Works Laboratories, Corning, N. Y.

In this short paper the author presented for consideration a simple mathematical expression for devitrification rate (relative to a maximum rate) as a function of temperature and which was derived from a consideration of free energy changes. If the liquidus temperature and the viscosity relations are known, the relative rates of crystal growth may be computed from this expression. Good agreement was obtained when computed rates were compared with those observed by Dietzel.

Further work is necessary before absolute rates can be predicted.

11. Effects of Replacing Dolomitic Lime by Baryta upon Some Properties of Glass

by Vincent E. Wessels, N. Y. State College of Ceramics, Alfred, N. Y.

Due to the decreased cost of barium materials and the increased use of such materials in commercial glass manufacture, the present investigation was undertaken to

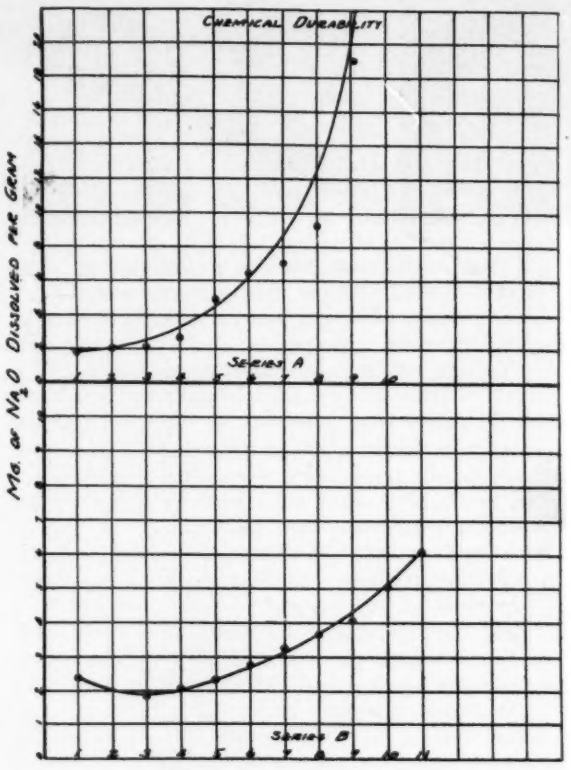


Fig. 1. Chemical Durability.

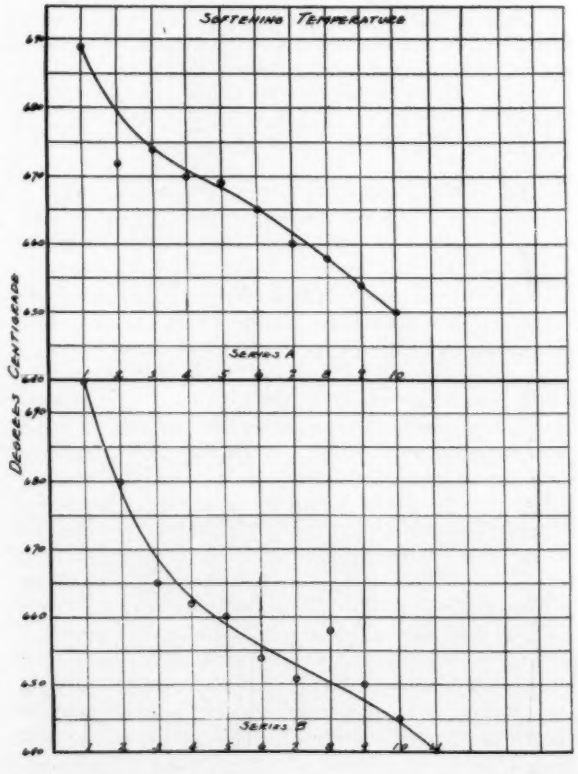


Fig. 2. Softening Temperature.

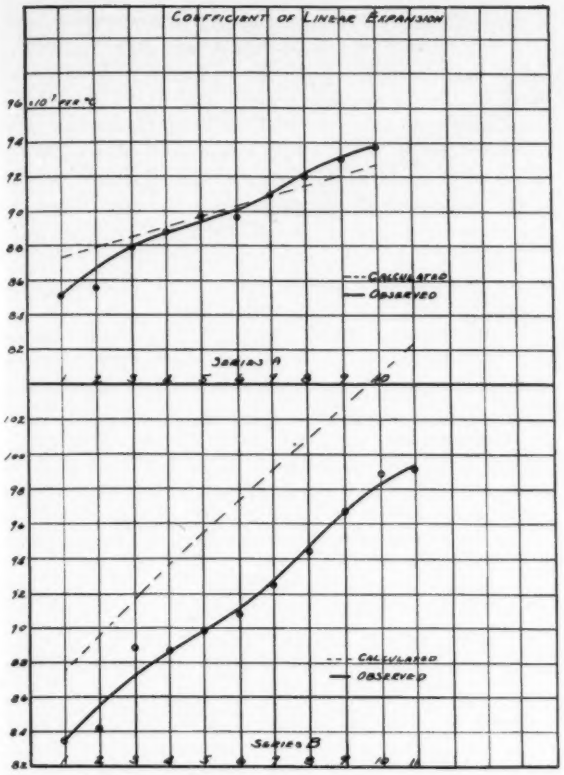


Fig. 3. Coefficient of Linear Expansion.

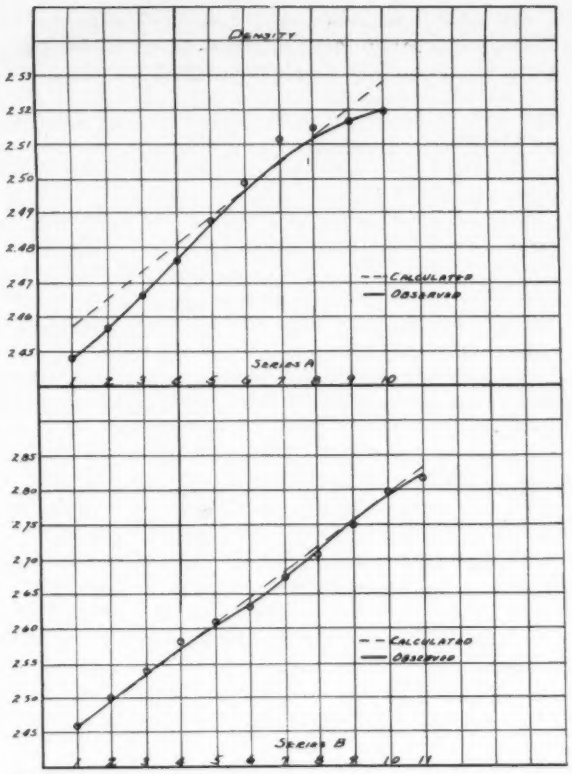


Fig. 4. Density.

determine the effect on various properties of glass when baryta replaces dolomitic lime, by both weight per cent and in molecular proportions. A complete and concise review of the literature was given before describing the present work.

Batches weighing 1,000 grams each were melted in a small gas fired pot furnace. To insure homogeneity the melts were poured several times from one crucible to another. The lime used in the batches was a freshly burnt dolomitic lime. Barium was introduced as a carbonate rather than as a sulphate because of its cheapness and because it reacts more readily with the silica. A small amount of salt cake was used in all batches. The compositions of the various glasses are given in Table I.

The various properties measured and the method of measurement are briefly as follows: the durability of the samples was measured by treating glass grains of 40-50 mesh with distilled water at 90°C for 24 hours. The extracted alkali in the water was titrated with n/20 HCl using phenolphthalein as the indicator. The results are shown in Fig. 1. In the determination of the softening point, the standard method of Littleton was employed. Results are given in Fig. 2. Thermal expansions were made with an Ames dial arrangement using a quartz rod as a standard. Results are shown in Fig. 3. Density determinations (Fig. 4) were made by the usual immersion method; index of refraction by comparison with oils of known index and the determination of elasticity by the use of glass rods, 5 mm in diameter and 33 cm long, resting on knife edges and loaded at the center, the deflections being measured by means of an optical lever device.

During the melting and working of the glasses, devitrification tendencies, ease of melting, working and other related properties were noted. It was concluded that when barium replaces dolomitic lime in weight per cent that:

1. The chemical durability of the glass decreases slowly at first, then very rapidly;
2. Softening temperature is lowered;
3. Coefficient of linear expansion is increased;
4. Density increases almost as a linear function;
5. The modulus of elasticity seems to be slightly lowered;
6. The refractive index is lowered slightly;
7. The melting time is decreased;
8. Working properties of glasses are improved.

TABLE I

Glass No.	SiO_2	Na_2O	CaO	MgO	BaO
A_1	74.0	17.0	5.2	3.8	..
A_2	74.0	17.0	4.7	3.3	1.0
A_3	74.0	17.0	4.1	2.9	2.0
A_4	74.0	17.0	3.5	2.5	3.0
A_5	74.0	17.0	2.9	2.1	4.0
A_6	74.0	17.0	2.3	1.7	5.0
A_7	74.0	17.0	1.8	1.2	6.0
A_8	74.0	17.0	1.2	0.8	7.0
A_9	74.0	17.0	0.6	0.4	8.0
A_{10}	74.0	17.0	..	..	9.0
B_1	74.1	17.0	5.2	3.7	..
B_2	72.7	16.7	4.6	3.3	2.7
B_3	71.3	16.4	4.0	2.9	5.4
B_4	70.0	16.1	3.4	2.5	8.0
B_5	68.8	15.8	2.8	2.1	10.5
B_6	67.6	15.5	2.3	1.7	12.9
B_7	66.4	15.2	1.9	1.3	15.2
B_8	65.2	15.0	1.3	1.0	17.5
B_9	64.1	14.7	0.9	0.6	19.7
B_{10}	63.0	14.5	0.4	0.3	21.8
B_{11}	62.0	14.2	..	..	23.8

The same conclusions are reached when barium is substituted in molecular proportions except that the durability increases slightly at first and then decreases.

12. Fourier Analysis of X-Ray Patterns of Vitreous SiO_2 and B_2O_3

by B. E. Warren, Mass. Inst. of Technology, Cambridge, Mass.

Continuing his previous work on the structure of glasses, Dr. Warren has repeated his earlier work on vitreous SiO_2 and B_2O_3. The X-ray scattering curves for these two materials were obtained by the use of a vacuum camera, utilizing both monochromatic molybedum and copper radiations.

In his earlier work, the scattering curves so obtained were subjected to a mathematical analysis in order to obtain the distribution curve. In the present work use was made of the newer Fourier analysis method. The Fourier analysis of the scattering curve gave directly a curve that represented the distribution of neighboring atoms about any one atom. In the case of vitreous SiO_2, the distribution curves so obtained definitely established the tetrahedral silicon-oxygen network previously found. The B_2O_3 distribution curve indicated a triangular coordination, each boron being surrounded by three oxygens, and each oxygen being shared between two borons.

With both SiO_2 and B_2O_3, the inter-atomic distances found were in excellent agreement with the results of previous crystalline investigations.

Emphasis was placed on the importance of the Fourier method of analysis of glass diffraction patterns, and it was shown that the distribution curves obtained by this method were unique and that no assumptions (such as was required in previous investigations) as to the structure are involved.

13. Motion Picture Analysis of Annealing

by Howard R. Lillie, Corning Glass Works Laboratories, Corning, N. Y.

Instead of being presented in the form of a paper this subject was given in the form of an explanatory talk followed by an actual demonstration of several films taken by Dr. Lillie in his studies on the analysis of annealing by means of motion pictures.

The theory of the Babinet compensator and its use was described before the showing of the motion pictures. Pictures of the compensator field were taken at definite intervals during the annealing process. Analysis of each frame thereby facilitated the determination of relative stress release rates at different depths in the glass sample. The use of suitable time intervals also enabled the viewing of the entire annealing process in a few minutes.

14. The Electrical Conductivity of Glass in the Annealing Zone as a Function of Time and Temperature

by J. T. Littleton and Warren A. Wetmore, Corning Glass Works Laboratories, Corning, N. Y.

The electrical resistance of glass depends upon the degree of annealing. Previous measurements of this property have been made on unstabilized glass, the degree of stabilization changing during the measurement. It was therefore of interest to determine the electrical properties of glass which had been stabilized at each temperature of measurement. In these experiments a soda-potash-lead glass having an annealing point of 431°C and a strain point of 395°C was used. The apparatus used and the method of measurement was fully described.

The measurements were made on chilled glass, annealed glass and on stabilized glass. The annealing curves, stabilizing temperatures and chilling treatments were given in detail. The chilled samples all showed an increase of resistance with time while the annealed samples at the higher temperatures showed a decrease. This was due to the fact that the initial state of the chilled glass corresponded to the equilibrium condition of some higher temperature while the annealed glass corresponded to that of a lower temperature.

In the summary of the results it was shown that the log of resistance of a stabilized glass varies linearly with 1/T, where T is the absolute temperature. The break in the curve which is usually thought to denote a transformation point was not present. The log of resistance of glass as measured during increasing temperature was found to be linear with 1/T to a certain temperature depending upon the rate of temperature increase and the previous thermal history of the sample.

15. Circulation of Glass in Tanks

by F. W. Preston, Butler, Pa.

By means of a description of the circulation of water in the Mediterranean and the Black Sea and by experiments with water columns connected by capillary tubes, it was shown that the circulation at the throat of a glass tank; i.e., the forward current from the melting end to the working end just under the sill of the bridge, and the countercurrent from the working end to melting end in the lower part of the throat, arises from the presence of two bodies of liquid of different density in contact with each other.

The circulation in the melting and refining chambers was shown to be much more complex. In the melting end, at the glass surface, there is a superficial circulation, outwards at the surface and back just below the surface that is due to the heating of the glass at its surface. When batch is added to the furnace an additional circulation is set up. The batch, being lighter than the glass, floats in piles on the surface with about three-fifths of its substance below the glass level. Being cold, it chills the surrounding glass which then tends to sink and set up a downward circulation. Batch and frothy glass, being light, tends to stay on the surface and maintain a circulation independent of what goes on below the surface.

In the refining end, the throat current through the upper part of the tank in a forward direction, rises sharply by the bridge wall and when it reaches the surface it tends to spread out in all directions towards the working end of the tank.

The model experiments of Schield and the mathematics concerned were discussed at length, and the conclusion was reached that it is virtually impossible to make a model that would represent the behavior of a glass tank and from which conclusions could be drawn with any assurance.

In the discussion of flux line corrosion, it was shown that two phenomena are occurring at the same time. Chemical attack and mechanical trenching actions were responsible for the V-shaped valleys found in eroded tank blocks. Additional data concerning these subjects will be presented in detail in a later paper.

16. Routine Determination of Boron in Glass

by Francis W. Glaze and A. N. Finn, National Bureau of Standards, Washington, D. C.

This paper is presented in full on page 156 of this issue of The GLASS INDUSTRY.

17. Measurements of the Relative Hardness of Glasses

by Chauncey G. Peters and Frederick Knoop, National Bureau of Standards, Washington, D. C.

Considering hardness as the ability of glass to resist abrasion or being scratched or shattered when brought in contact with a sharp point of some other substance, an attempt was made to make quantitative measurements which would place different glasses according to some definite hardness scale.

Measurements were made with several different hardness testing machines and by scratching methods. In these tests, the glass shattered, giving unreliable results.

An attempt was made to judge the hardness from the width of straight edged lines free from shatter, cut with diamond tool ground to perfect edges and point. Here the width of the lines ranged from 2.5 microns for the borosilicate crown to 5 microns for the dense flint. Since the variation in the measurements of the line width with the micrometer microscope, or by spacing the lines so that the edges touched were from .5 to 1.0 micron, this method did not give an open scale. Furthermore, the diamond point wore rapidly making tool cost prohibitive for any commercial testing.

A method was then resorted to that makes use of a diamond tool ground in form of an axe blade similar to the steel tool used by Middleburg to test car wheels. This edge is pressed under various loads into the surface of the glass. The lengths of the imprints were measured with a micrometer microscope. This method gave results consistent within about one per cent when homogeneous samples of glass were tested. The axe blade tool was, however, difficult to grind so the form was modified to that of an elongated four sided pyramid. This tool makes a diamond shaped impression about 200 microns across the long and 10 microns across the short diagonals. The length of the marks can be measured with an accuracy of one micron.

These tools have shown no apparent wear or tendency to break down after two months of service.

Some of the results obtained are given in the following tables. The applied loads $W_1=2.8$ oz; $W_2=3.4$ oz; $W_3=7.9$ oz; and $W_4=13.7$ oz. Table I shows results obtained from different crystals of the Moh's scale which place them according to the accepted order. Borosilicate crown falls about half way between quartz and feldspar and the dense flint about half way between feldspar and apatite. Large variations were found in the different direction for calcide.

Table II shows the results obtained from some of the glasses investigated. A major part of the work was done on the five optical glasses obtained from the optical glass section, which were very homogeneous and gave reproducible results.

The first two columns show the results obtained with an axe type tool, having an edge that was a segment of a circle of ½" diameter. Columns 3 and 4 give similar results from a tool with 5/16" diameter, and columns 5 and 6 were obtained with a pyramid type tool. Each tool places the material in the same order. The last two columns show the results obtained from lines cut with a diamond ground to a perfect point. The second set shows the effect of the wear on the point.

In this work, attempt was made to obtain quantitative measurements of the relative hardness of different brittle materials without causing rupture or shattering.

Examination of the impressions made by the diamond indicate that the glass is permanently compressed. No

TABLE I

Axe-Type Tool

SUMMARY OF MOHS' SCALE

	W-1	W-2	W-3	W-4			
8 Topaz	239	273	420	534			
7 Quartz	258	292	469	626			
B. S. C.	...	...	538	680			
6 Feldspar	388	407	576	735			
D. F.	...	...	622	775			
5 Apatite	402	438	639	850			
4 Fluorspar	559	592	801	990			
3 Calcite	544	614	844	994		1st	Direction
	647	676	1010	1339	45° to	"	"
	1047	1126	1405	1825	90° to	"	"
2 Gypsum	1027	1143	...	...			

TABLE II

COMPARISON OF GLASSES

	Axe Type Diamond No. 1 ½" Diam.		Axe Type Diamond No. 3 5/16" Diam.		Pyramid Type Diamond No. 4		Line Width	
	W-3	W-4	W-3	W-4	W-3	W-4	1st Set	2nd Set
Crystal Quartz	469	626	...	...	279	380	...	...
Fused Quartz	541	692	...	...	...	...	...	...
B.S.C. 947	539	680	474	598	314	433	...	...
B.S.C. 643	543	687	...	...	315	432	3μ	2μ
L.B.C. 947	564	700	507	631	334	462	...	...
L.B.C. 651	574	715	...	...	333	461	2.5μ	2μ
Feldspar	576	735	...	...	348	464	...	...
Pyrex	583	701	...	...	...	...	...	...
Disc 654	591	733	...	...	...	...	...	...
B.F. 766	588	736	520	652	355	487	...	...
B.F. 662	591	740	...	...	357	488	3μ	3μ
Corning 015	595	734	...	...	...	...	...	...
Corning 2 015	607	760	...	...	...	...	...	...
M.F. 939	606	762	540	667	371	511	...	...
M.F. 727	625	785	...	...	375	512	4μ	2μ
M.F. Lens	618	765	...	...	...	...	...	...
D.F. 935	622	775	557	685	378	517	...	...
D.F. 640	627	775	...	...	380	520	5μ	2μ
Apatite	639	850	...	...	445	603	...	...
Apatite	...	...	...	...	408	582	...	...

broken particles were visible and a bright line made by the diamond edge extends across the center of the impression. Examination of a row of marks about ¼ mm apart under polarized light, showed a green strip crossing the centers of the marks on a red color for the rest of the field. Applying 11 different loads ranging from 1 oz. to 17 oz., it was found that the loads were proportional to the areas of the marks. For each load, the pressure was computed as approximately 700,000 lbs. per square inch. The range was from 675,000 to 738,000 lbs. which is comparable with the uncertainty of measurements of the load and areas.

18. The Scratch-Resisting Power of Glass and the Measurement Thereof

by James Bailey, Bailey & Sharp Co., Inc., Hamburg, N. Y.

Many investigators have studied the resisting power of a glass surface to injury by abrasion and scratching, with the result that a wide variety of tests have been developed for the purpose of measuring this property. These tests vary from a determination of the pressure required to cause rupture of the surface to a measurement of the width of a scratch produced by a diamond or other hard object. A number of tests based upon the quantity of glass ground away by an abrasive under definitely controlled conditions have also been used. These latter, however, are obviously tests on the body of the glass rather than of the surface.

All of these methods yield data which are of value but these methods do not give the same order of hardness for different glasses nor do the results agree in many instances with our usual conception of the relative hardness of different glasses. It is evident, after a brief study of the problem, that the resistance of a glass surface to scratching depends upon a number of factors other than mechanical strength of the body of glass.

A preliminary examination of various glass articles which had become scratched in use showed that the surface injuries consisted of small hair-line scratches, deep gouges, relatively wide shallow surface abrasions, bruises and conchoidal fractures. The scratches could be divided roughly into two classes, namely, surface abrasions which were very shallow and appeared under the microscope somewhat like chalk marks and scratches produced by crushing the surface, these latter being associated with cracking and splintering of the surface and of the adjacent glass. Many scratches, showed distinct weathering. An assortment of bottles which had been repeatedly sterilized showed that some of the apparently bad scratches and bruises had been small when first formed but had been wedged open and spread by chemical action during the sterilizing process.

Other scratches which occurred on high soda content art glass were found to be chiefly the products of weathering of the body of the glass after the original surface had been worn off by slight abrasion.

Experiments wherein glasses were scratched by drawing across them the corner of another piece of glass showed that very slow movement and heavy pressure produced scratches by crushing the surface. As the velocity of rubbing increased, the sliding point became heated and softened giving a chalk mark like abrasion. The ability of one material to scratch another depends, therefore, upon the velocity of motion and upon the refractoriness of the material forming the point. Quartz glass could be easily scratched by ordinary glass when the motion was slow but quartz glass would scratch common glass at any ordinary speed because it did not fuse under the heat of friction.

The preliminary work showed that a test for the scratch resisting power of a glass surface should test the surface as it exists upon the article. All thermal effects should be eliminated as far as possible and because of the lesser chemical durability of the inner glass, the conditions causing the initial rupture of the surface should be used as a measure of the scratch resisting power of the particular surface.

The method adopted for testing the surface consisted of rolling a ⅛" diameter steel ball over the surface, the ball being pressed against the glass by a steel plate in such manner that the pressure increased as the ball rolled along. When the pressure became sufficiently great, the glass surface cracked leaving the path of the ball marked by a series of partial conchoidal fractures. The pressure at which the first breaks occurred was used as a measure of the hardness.

It was found that natural surfaces such as those of drawn window glass varied in hardness, some spots being less than half as hard as other areas. Fused silica glass had a value of 10 to 12 lbs.; common window glass gave values of about 25 lbs., while some glass with a high alumina content gave much higher values. Ground and polished surfaces were softer than fire-polished surfaces on the same glass, and strained glass had a harder surface than the same glass in the annealed state.

Slides illustrating various types of new scratches, weathering effects along scratches, weathering effects in cracks and fractures and a series of the ball tracks left in a glass surface by the tests were shown.

19. The Effect of Alumina on the Surface Tension of Molten Glass

by C. W. Parmelee and C. G. Harman, Dept. of Ceramic Eng., University of Illinois, Urbana, Ill.

The determination of the surface tension of molten glasses is of both practical and theoretical value. Surface tension effects the rate of fining of the glass, the ease of fire polishing operations and influences the beauty of glass surfaces. Since surface tension is a property of liquids and solutions, it should have some connection with the structure of such materials. The present experiments were undertaken to determine the effect of alumina on the surface tension of glass and to study the technique involved in the measurement of this property by the maximum bubble pressure method.

Previous work on the measurement of the surface tension of glass was first briefly reviewed and the apparatus and theory of the method used in the present investigation given in detail, stressing the mathematics involved.

The glasses used were prepared from the purest reagent chemicals available and were melted in platinum crucibles, crushing and remelting until the desired homeogeneity was obtained. Iron contamination from the mortar was removed either by an electromagnet or by digestion with hydrochloric acid. The alumina was added to the following base glass: 16.02 per cent Na_2O, 7.77 per cent CaO, 3.02 per cent MgO, 73.18 per cent SiO_2; so that the ratio SiO_2: Na_2O: MgO: CaO was the same in every glass.

Surface tension measurements were then made on the plained glass after the desired temperature had been reached. The method used required some skill in manipulation to enable the operator to determine surface tensions readily and precisely. Different readings on the same material at the same temperature varied about 0.3 per cent from the average. The accuracy of the method varies somewhat depending upon the condition of the glass surface. If the glass has not been thoroughly fined, the values will be in error.

The surface tensions of the soda-lime-silica glasses were found to increase by the addition of Al_2O_3 (Table I). The increase being rapid up to 2 per cent Al_2O_3. Between 2 per cent and 8 per cent Al_2O_3, the increase was more gradual. The surface tensions of the glasses studied was in the order of 300 dynes per cm. and the temperature coefficient of surface tension was about the same for the various glasses used. The data was compared with that of other investigators and in general, after allowing for differences in glass composition, very good agreement was attained.

TABLE I[1]

Alumina	Surface Tension Dynes per Cm.	
%	1250°C	1400°C
Base glass	297.5	293.5
1.96	319	316.5
3.83	326	323.5
7.41	338	335.5

[1]Taken from curves.

Attempts were also made to determine the specific gravity of the glasses at elevated temperatures by the loss in weight of a platinum sphere suspended in the molten glass. The results were unsatisfactory.

20. The Constitution of Lead Oxide-Silica Glasses: Part I. Atomic Arrangement

by George J. Bair, Dept. of Ceramic Engineering, Pennsylvania State College, State College, Pa.

A series of lead oxide-silica glasses varying in composition from 10 to 60 mol per cent of PbO were prepared and diffraction patterns obtained. The observed intensity curves derived from these patterns were matched with curves calculated from assumed structures by means of the scattering equation of Zernicke and Prins. The atomic arrangement finally derived consists of a continuous, randomly oriented, three dimensional network of silicon-oxygen tetrahedrons and lead atoms. There was no indication of molecular or aggregate formation and no discrete atomic grouping of this nature was postulated to explain the X-ray evidence. The study of this series of glasses further substantiates the results obtained by Warren and Loring for soda-silica glasses and is in accord with Zachariasen's picture of glass.

21. The Constitution of Lead Oxide-Silica Glasses: Part II. The Correlation of the Physical Properties with the Atomic Arrangement

by George J. Bair.

Various physical properties of the lead oxide-silica series of glasses were studied to obtain data on transformation points, equilibrium degrees of aggregation, etc., to determine whether these phenomena are in accord with the atomic arrangement of glass as derived from X-ray.

The expansion of glass rods of this series during heating was determined by a method which imposed no load on the specimens. Sharp reproducible breaks were obtained in the curves. Heating and cooling curves of the glasses showed a reversible heat effect at the temperature of these "transformation points." An explanation of these discontinuities based on the continuous network structure, describes them as the temperature at which the weak bonds in the structure spontaneously break—the temperature at which the solid glass becomes a liquid. Explanations of the apparent shift of the transformation point and absence of the transformation point in some property-temperature curves are also presented.

The change of the rate of elongation of a glass fiber under load is attributed to a delayed elastic distortion of the atomic network. It is equivalent to putting strain into the glass. An equation for the elongation-time curve of a glass fiber at constant temperature was derived from Adam's and Williamson's annealing equation. This derived equation is:

$$E = ct + M \frac{t}{t + N},$$

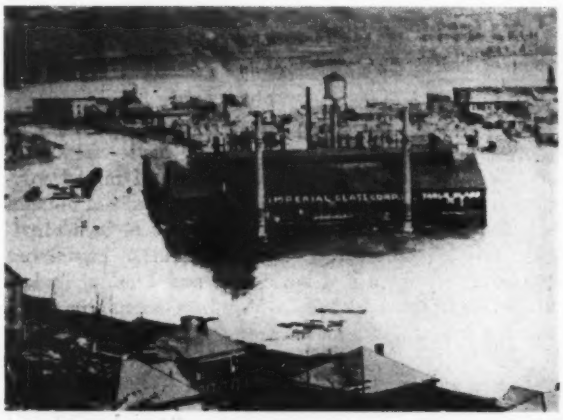
where: E is the elongation, t is the time, c, M and N are constants.

The effect of thermal treatment on the shape of the elongation-time curve is due to the amount of distortion the atomic network is capable of sustaining at any temperature and not due to any approach of an equilibrium degree of aggregation.

It is concluded that the picture of lead oxide-silica glasses as continuous, randomly oriented, three-dimensional network of atoms possessing neither discrete molecules nor aggregates in its structure, is sustained by this investigation.

LESSELLS TO M. I. T.

The appointment of John M. Lessells, prominent consulting engineer of Swarthmore, Pa., as associate professor of mechanical engineering at the Massachusetts Institute of Technology has been announced. He will be occupied with teaching and research in the field of engineering materials. In partnership with Professor G. B. Karelitz, Mr. Lessells has been identified with some of the mechanical details of the 200-inch telescope to be erected on Mount Palomar.



The Imperial Glass Corporation, Bellaire, Ohio, during the recent floods. Things are back to normal now, both here and in the other glass plants affected by the raging waters.

ROUTINE DETERMINATION OF BORON IN GLASS*

By FRANCIS W. GLAZE AND A. N. FINN

A method for the routine determination of boric oxide in glass, based on the "partition" of boric acid between water and ether in the presence of hydrochloric acid and ethanol, has been developed. A slightly acid solution of the fusion of the glass is shaken with ether and ethanol, and the boric acid in the ether layer titrated. The "partition coefficient" is 0.403 *at* 25°C ± 2°. *The advantages of this method are its speed and simplicity without material sacrifice of accuracy.*

Boric oxide between 0.7 *and* 16 *per cent can be rapidly and accurately determined. Lime, magnesia, alumina, soda, iron, and arsenic, in amounts likely to be found in glass, do not interfere. Barium, fluorine, and abnormally large amounts of iron interfere slightly. Zinc interferes seriously.*

THE methods now used for the determination of boric oxide in glass, silicate minerals, and similar materials are of two general types: those requiring distillation of the boron and those not requiring it. Examples of the former are the Gooch[1], and the Chapin[2] methods; of the latter, the Wherry[3], with its various modifications, and the Mylius[4] methods.

For occasional determinations of boric oxide, the distillation methods are cumbersome because they require a rather elaborate "set-up" and a large supply of special reagents. The non-distillation methods can be handled more easily, but the necessary filtrations are time-consuming and the results are probably not as accurate as those obtained by distillation.

Since the determination of boric oxide in commercial glasses has become increasingly necessary in recent years, because of the more frequent use of borax or boric acid in making such glasses, a rapid, simple, and reasonably accurate method is desirable. In connection with a study of experimental glasses at the National Bureau of Standards, a method possessing these advantages has been developed. It is especially useful if many determinations of boron are to be made on glasses of the same type. It is based on the relative solubility of boric oxide in water and an ether-ethanol mixture and involves a special application of Henry's Law—the so-called "partition law." Ether alone proved unsatisfactory because it extracted only traces of boric oxide from the aqueous solution.

As boric oxide is reasonably soluble in alcohols, it was decided to use mixtures of absolute ethanol and ether, inasmuch as Herz and Kurzer[4] have shown that the "partition law" applies in the case of mixed solvents. To determine the most effective mixture of ethanol and ether, a series of solutions of boric acid in ethanol-water mixtures was prepared, each solution containing approximately 0.05 g of boric acid and 1 ml of hydrochloric acid (sp. gr. 1.18) in 50 ml. One solution contained 5 ml of absolute ethanol in 50 ml of solution, the others 10, 15, 20, 25, and 30 ml, respectively. To each of these solutions in a calibrated 100 ml glass-stoppered graduate were added 50 ml of ether. The liquids were thoroughly mixed by vigorous shaking and allowed to stand until the ether and water layers had separated. The volumes of the layers were read to the nearest 0.1 ml. The concentration of the boric oxide in the ether layer was determined as follows.

A 50-ml portion was pipetted into a 250 ml Erlenmeyer flask, two drops of *p*-nitrophenol added and the solution titrated to the *p*-nitrophenol endpoint with 0.5 N sodium hydroxide. One ml of phenolphthalein was added and the titration continued to the phenolphthalein endpoint. A volume of 0.5 N sodium hydroxide equal to three times that used between the two endpoints was added and the flask vigorously shaken. Its sides were washed down with distilled water and the volume of the aqueous layer was made up to 40-50 ml. The ether and ethanol were quickly removed by first heating on the steam bath and finally by boiling over a free flame. The volume was adjusted to 35-45 ml with distilled water, the solution allowed to cool, and then made just acid with 0.5 N hydrochloric acid to *p*-nitrophenol. After warming on the steam bath, the carbon dioxide was removed by boiling under reduced pressure until cool. The solution was then titrated to the *p*-nitrophenol endpoint with 0.1 N barium hydroxide, mannitol added, and the boric oxide titrated.

The amount of boric oxide in the total ether layer was calculated from the amount of boric oxide found in the 50-ml aliquot portion and the boric oxide in the water layer was obtained by difference. From the concentration of boric oxide in each layer, the "partition coefficient"

$$\left(K = \frac{C_{Et_2O}}{C_{H_2O}}\right)$$

was calculated. The values of K for the mixtures containing 5, 10, 15, 20, and 25 ml of ethanol were 0.044, 0.100, 0.189, 0.263 and 0.440, respectively. The relation between these values and the volume (V) of ethanol added can be expressed by the empirical equation:

$$K = 0.000637V^2_{EtOH} + 0.032$$

The addition of 30 ml of absolute ethanol produced complete miscibility. Hence, 25 ml of ethanol was used in the succeeding experiments as that volume gave the maximum value of K and could be conveniently measured by means of a standard pipette. The data in Table 1 indicate that the "partition coefficient" is practically independent of the quantity of boric oxide present, and boric oxide is, therefore, in the same state of association in each of the layers.

The effect of shaking was studied in a series of experiments using a sample containing about 0.05 g of boric oxide. The solutions were shaken by hand three

* Publication approved by the Director of the National Bureau of Standards of the U. S. Department of Commerce.

1. F. A. Gooch, Proc. Am. Acad. Arts and Sci. 22, 167 (1886); Bull. U. S. Geol. Survey No. 42, 64 (1887); Chem. News. 55, 7 (1887).
2. W. H. Chapin, J. Am. Chem. Soc. 30, 1691 (1908).
3. E. T. Wherry, J. Am. Chem. Soc. 30, 1687 (1908).
4. W. Herz and Alfred Kurzer, Z. Elektrochem. 16, 240 (1910).

Table 1. Effect of the amount of B_2O_3 on K.

B_2O_3 sol. + 1 ml HCl (sp.gr. 1.18) + H_2O = 25 ml.

25 ml C_2H_5OH (abs.) and 50 ml $(C_2H_5)_2O$ added.

(Room Temperature)

B_2O_3 added (g)	0.01099	0.03297	0.05495	0.08243	0.1099
$(B_2O_3)_{Et_2O}$ (g)	.00513	.01490	.02488	.03712	.04975
$(B_2O_3)_{H_2O}$ (g)	.00586	.01807	.03007	.04531	.06015
Et_2O layer (ml)	62.4	62.6	63.1	63.2	63.1
H_2O layer (ml)	35.2	34.1	34.0	33.7	33.8
$C_{Et_2O} \times 10^4$ (g/ml)	0.822	2.380	3.943	5.873	7.884
$C_{H_2O} \times 10^4$ (g/ml)	1.665	5.299	8.844	13.45	17.90
$K = C_{Et_2O}/C_{H_2O}$	.494	.449	.446	.437	.443

Average K = 0.444 *

*The average in this and succeeding tables is adjusted and is obtained by means of the equation, Av. $K = \frac{\Sigma(g\ B_2O_3 \times K')}{\Sigma(g\ B_2O_3)}$

where K' is the value computed from the analytical data in each experiment.

times a minute and about five seconds each time. As the values of K were practically constant for shaking periods ranging from 5 to 30 minutes, it was concluded that, for these clear solutions, equilibrium is reached in less than five minutes. In this series of experiments it was found that the substitution of 95 per cent for absolute ethanol caused a decrease in the average value of K from 0.444 to 0.374.

The effect of variations in temperature (t) on the value of K was investigated, using a 20-minute shaking time and amounts of boric oxide varying from 0.14 to 0.73 g. At 1.5, 10, 21 and 30.5°C the values of K were 0.613, 0.520, 0.453 and 0.409, respectively. The variation of K with temperature is expressed by the equation, $K = 0.668\text{-}0.0469\sqrt{t}$ (See curve 1, fig. 1).

1. Effect of the amount of flux (sodium carbonate) used in decomposing the sample on the "partition coefficient."

Although 0.5 g samples of most glasses can be completely decomposed after fusion with 1 g of sodium carbonate, if intimately mixed beforehand, tests were made to determine the effect of varying the amount of flux by dissolving 1 g and 2 g respectively, of sodium carbonate in varying amounts of a standardized aqueous solution of boric acid, and then determining the boric oxide in the ether layer as previously stated. Herz[5] states that sodium chloride decreases the solubility of boric acid in water, and sodium chloride equivalent to the amount of sodium carbonate used seems to have a greater effect in decreasing its solubility in the ether-ethanol layer. This can be seen by comparing the values of K in Tables 1 and 2. These tables also show that sodium chloride decreases the volume of the water layer.

The effect of temperature variations on the value of K in the presence of sodium chloride was also studied. No work was done in the region of 0°C in this case after it was found that the value of K at 10°C fell off rapidly for amounts of boric oxide in excess of about 0.05 g. This did not happen in the experiments carried out at 21°C, so it would seem that there would be no advantage in using a temperature much lower than 20°C for the extractions. At temperatures of 10, 21 and 31.5°C, K was found to be 0.503, 0.422 and 0.373, respectively, and the variation of K with temperature is expressed by the equation, $K = 0.673\text{-}0.054\sqrt{t}$. In Fig. 1 the effects of changes in temperature (curve 2) and the amount of flux (sodium carbonate) used on K (curve 3) are graphically shown.

2. Experimental work on glasses and interfering elements.

One-half-gram samples of Standard Sample No. 80[6], which contains no boron, were fused in a platinum crucible with 1 g of sodium carbonate, cooled, digested in the crucible with varying amounts of a standardized aqueous solution of boric acid, and neutralized with hydrochloric acid (1:1) to the *p*-nitrophenol endpoint. The boric oxide in the resulting mixture, which contained some precipitated silica, was determined as previously outlined. The results obtained show that K is constant up to about 0.08 g of boric oxide; above that amount it is definitely low. Consequently, amounts of boric oxide up to 16 per cent can be conveniently determined by this method. Since the value of K obtained

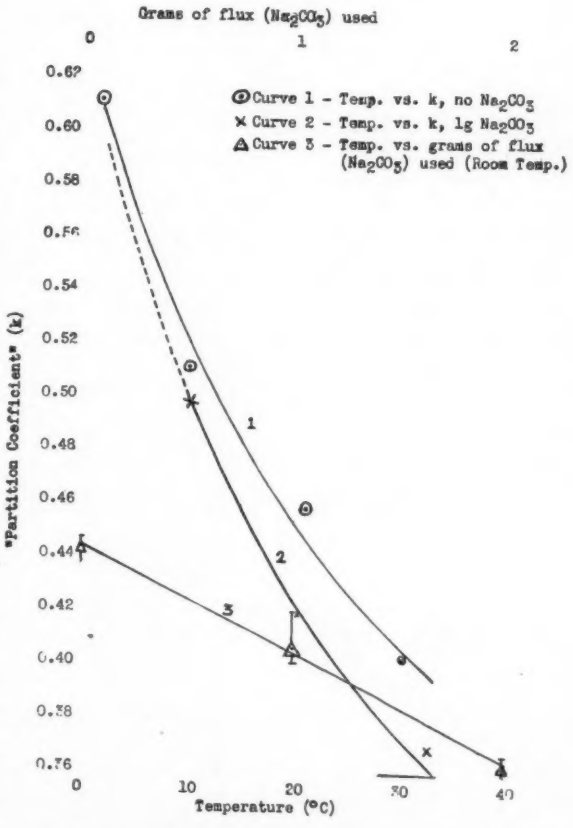


Fig. 1. The effect of variations in temperature and in the amount of flux used in decomposing the sample on the "partition coefficient."

in these experiments (0.408) is the same as that obtained when 1 g of sodium carbonate was used (Table 2), silica, lime, magnesia, and soda do not interfere when present in amounts equivalent to those in Standard Sample No. 80.

Since commercial glasses may contain appreciable amounts of arsenic, aluminum, barium, zinc, iron, and fluorine, tests were made to determine if these elements interfere. The tests were made by adding appropriate soluble salts, in varying amounts, to fusions of several Standard Samples of glass, and determining the boron.

Arsenious and arsenic oxides were added in amounts between 0.002 and 0.025 g. Arsenious oxide up to 0.005 g and arsenic oxide up to 0.01 g caused no trouble; above these amounts a plus error resulted in the value of K.

Alumina up to 0.05 g had no effect.

One-hundredth of a gram of barium oxide did not affect the determination of boric oxide in Standard Sample No. 92, but caused low results on Standard Sample No. 93. However, the interference of small amounts of barium oxide can be avoided by adding a drop of sulphuric acid (1:1) when decomposing the fusion.

The equivalent of 5 per cent of zinc oxide added to Standard Sample No. 80 gave a titration indicating 3.5 per cent of boric oxide. This and other work leads to the conclusions that in the presence of zinc this method cannot be used until it has been removed and also that zinc chloride may lower the "partition coefficient."

Iron, in amounts usually present in glass, gave no trouble; but when it was added in amounts equivalent to 1 per cent of ferric oxide, the color of the ferric chloride formed from it masked the *p*-nitrophenol endpoint.

The presence of approximately 6 per cent of fluorine caused a blank about twice that of the normal blank (0.56 ml of barium hydroxide solution as against 0.27 ml). Furthermore, low values of the "partition coefficient" were obtained, probably on account of the formation of potassium fluoborate or possibly sodium fluoborate which, according to Smith, Hamilton and Graham[8], is quite insoluble under the conditions of the experiment.

Table 2. Effect of NaCl on K

(Room Temperature)

Na_2CO_3 added (g)	1.000	1.000	1.000	1.000	1.000	2.000	2.000
B_2O_3 added (g)	0.01075	0.02150	0.03225	0.04300	0.05375	0.10000	0.20000
$(B_2O_3)_{Et_2O}$ (g)	0.00567	.01144	.01698	.02234	.02798	.05387	.10774
$(B_2O_3)_{H_2O}$ (g)	.00508	.01006	.01527	.02066	.02577	.04613	.09226
Et_2O layer (ml)	71.9	71.6	71.6	71. 5	71.6	74.0	74.3
H_2O layer (ml)	26.3	26.6	26.6	26.6	26.6	23.4	23.1
$C_{Et_2O} \times 10^4$ (g/ml)	.789	1.598	2.372	3.124	3.908	7.280	14.50
$C_{H_2O} \times 10^4$ (g/ml)	1.932	3.782	5.741	7.767	9.688	19.71	39.94
K′	.408	.422	.413	.402	.403	.369	.363

Average K = 0.408 (1g Na_2CO_3)

Average K = 0.365 (2g Na_2CO_3)

It is evident from curve 2 of Fig. 1 that the effect of temperature on the "partition coefficient" cannot be disregarded. A constant temperature room would insure very satisfactory conditions for making boron determinations by this method and, unless one is available, proper temperature corrections must be made if one wishes to obtain reasonable accuracy. However, for routine work ordinary variations in the temperature of the laboratory will not produce serious errors in the determination of small amounts of boric oxide (up to 8 per cent) even if the temperature corrections are not applied. The error gradually increases for increasing amounts of boric oxide until, for 16 per cent, it becomes about 0.2 per cent (plus or minus, depending on whether the temperature is 2° below or above 25°C).

It can be seen from curve 3 of Fig. 1 that variations in the amount of flux used in decomposing the glass have a definite effect on K, but the effect is not as great as the temperature effect and is not serious, because a definite weight is much more easily obtained than a constant temperature.

Recommended Method of Analysis

REQUIRED reagents (1) Para-nitrophenol—One gram dissolved in 75 ml of ethanol (95 per cent) and made up to 100 ml with distilled water.

(2) Phenolphthalein—One gram dissolved in 100 ml of ethanol (95 per cent) and made up to 200 ml with distilled water.

(3) Hydrochloric acid, 0.5 N.

(4) Sodium hydroxide, 0.5 N.

(5) Barium hydroxide, 0.1 N.

(6) Ethanol, absolute.

(7) Ethyl ether, free from aldehyde and peroxide as indicated by test given below.

(8) Mannitol.

Analytical Procedure

GRIND 0.5 g of glass and 1 g of sodium carbonate intimately together in a mortar and transfer to a platinum crucible. Fuse at as low a temperature as possible and only as long as is necessary to effect complete decomposition. Cool, wash the lower surface of the lid, catching the washings in the crucible, and wash down the sides of the crucible with hot distilled water. Disintegrate the melt (with the aid of a platinum wire) on the steam bath and concentrate to about 5 ml. Cool and neutralize most of the alkali with HCl (1:1), guarding against loss of boron both by spattering and volatilization (by cooling). Add two drops of *p*-nitrophenol, complete neutralization dropwise, add 1 ml of concentrated HCl (sp. gr. 1.18), and transfer to a calibrated, 100-ml glass-stoppered cylinder. Dilute to 25 ml, add 25 ml of

5. W. Herz, Z. anorg. Chem. 66, 358 (1910).

6. The partial composition of Standard Sample No. 80 of the National Bureau of Standards, and of the other Standard Samples used in this work, is given in Table 4.

7. S. Palkin and H. R. Watkins, Ind. Eng. Chem. 21, 863 (1929).

8. C. M. Smith, E. H. Hamilton and J. J. T. Graham, J. Assoc. Official Agr. Chem. 14, 256 (1931).

Table 3. Results obtained with samples containing varying amounts of B_2O_3 when proper temperature corrections are made

Standard samples used	B_2O_3 present or added	Extraction temperature	Et_2O layer	H_2O layer	K * (calculated)	B_2O_3 ** present or added	B_2O_3 found	Difference
no.	g	°C	ml	ml		percent	percent	percent
80	0.00480	21.5	72.3	25.8	0.423	0.96	1.05	+0.09
80	.00959	23.0	72.7	25.2	.414	1.92	2.00	+0.08
80	.02467	24.0	72.6	25.4	.408	4.93	4.92	-0.01
80	.04934	26.0	73.0	25.0	.398	9.87	9.96	+0.09
80	.07401	26.0	72.8	25.3	.398	14.80	14.77	-0.03
92	.00350	24.5	72.7	25.3	.406	.70	.78	+0.08
80 and 93	.00629	19.0	72.1	25.5	.438	1.26	1.24	-0.02
80 and 93	.01257	17.5	72.1	25.8	.447	2.52	2.59	+0.07
80 and 93	.02515	18.0	72.7	25.5	.444	5.03	4.97	-0.06
80 and 93	.03772	25.0	72.4	25.9	.403	7.54	7.67	+0.13
80 and 93	.05030	25.0	72.5	25.7	.403	10.06	9.96	-0.10
93	.06287	27.0	72.6	25.4	.393	12.57	12.58	+0.01

(*) $K = 0.673 - 0.054\sqrt{t}$

(**) On the assumption that the "g B_2O_3 present" was in 0.5 g sample of glass.

absolute ethanol and 50 ml of ether[9] and shake intermittently for 20 minutes, noting the temperaure. Allow the layers to separate, record their volumes, and pipette off a 50-ml sample of the ether layer for analysis. To the 50-ml sample, in a 250 ml Erlenmeyer flask, add two drops of *p*-nitrophenol and titrate to the *p*-nitrophenol endpoint with 0.5 N NaOH. Read the burette, add 1 ml of phenolphthalein and continue the titration to the phenolphthalein endpoint. Add a volume of 0.5 N NaOH equal to three times that used between the two endpoints, and shake the flask vigorously. Wash down the sides with distilled water and make the water volume up to 40-50 ml. Boil off the ether and ethanol as quickly as possible[10], first on a water or steam bath and finally over the free flame to remove the last traces of ether and ethanol. Adjust the volume with distilled water to 35-45 ml, cool, and then make just acid with 0.5 N HCl. Warm on the steam bath for about one minute and boil under reduced pressure until cool to remove CO_2. Titrate to the *p*-nitrophenol endpoint with 0.1 N $Ba(OH)_2$, record the burette reading, add mannitol, and titrate the B_2O_3. One ml of 0.1 N $Ba(OH)_2$ is equivalent to 0.00348 g of B_2O_3. A blank determination should be made using a glass, preferably of similar composition, but containing no boron.

Table 4. Partial composition of standard samples

No.	80	93	91	92
	percent	percent	percent	percent
SiO_2	74.10	80.600	67.60	--
R_2O_3	.42	2.060	6.00	--
CaO	4.65	---	10.48	--
MgO	3.23	.027	.01	--
Na_2O	16.65	4.160	8.46	--
K_2O	0.04	.16	3.24	--
B_2O_3	none	12.76	none	0.70
Ignition loss = 0.30		F = 5.75		

The equation[11] for calculating the percentage of B_2O_3 in a 0.5-g sample, is as follows:

$$\text{Per cent } B_2O_3 = 4\,(B_2O_3)_{50Et_2O}\left[V_{Et_2O} + \frac{V_{H_2O}}{K}\right]$$

where $(B_2O_3)_{50Et_2O}$ is the grams of B_2O_3 in the 50-ml aliquot portion taken for analysis and V_{Et_2O}

(*Continued on page* 176)

SNAPPED AT THE ACS CONVENTION

(1) P. E. Harth; (2) H. K. Richardson; (3) Howard R. Lillie; (4) Dr. Alexander Silverman: (5) G. W. Morey; (6) Ernest Hommel; (7) Fred R. Motsch; (8) M. R. Scott; (9) Newshawks; (10) Dr. Sosman & E. C. Van Schoick; (11) Bailey & Sharp; (12) R. S. Bradley, E. C. Van Schoick, Mrs. H. E. Simpson, H. E. Simpson, E. L. Hettinger, Marie Echardt, V. V. Kelsey, C. E. Bales, R. D. Landrum; (13) Glass Division Lunch; (14) Dr. Taylor; (15) U. E. Bowes & J. F. Littleton; (16) Tillotson & Clark; (17) H. H. Bau; (18) Irwin Zeiller & V. H. Remington; (19) C. H. Peddrick, Jr; (20) Grover Babcock & Lois Lord; (21) F. C. Flint & S. R. Scholes; (22) V. V. Kelsey & C. E. Bales; (23) Dance Scene; (24) Urban E. Bowes & disciples; (25) Mary Radcliffe, L. J. Trostel, E. C. Van Schoick, Louis Navias, Dorothy Turner at Abstracters' Dinner; (26) O. A. Lyons, Clark & Wm. Horak; (27) C. D. Spencer, A. N. Finn, Swickard; (28) J. V. Kelsey, Frank Cermak & C. C. Treischel; (29) Colonel Purdy; (30) E. L. Hettinger & C. W. Parmelee. Staff Photographers; Messrs. Ernst, Hettinger and Spencer.

EFFECT OF ALUMINA ON THE DEVITRIFICATION OF SOME SODA-LIME GLASSES

By WM. HORAK AND D. E. SHARP

STUDIES of the effect of chemical composition on the devitrification of glass are complicated by the absence of any true measure of the velocity of crystallization, and by lack of data on the minimum velocity that could be accepted by any particular glass-making process. Nevertheless, considerable information on the possibility of devitrification occurring is available in equilibrium diagrams. However, these generally include only three component systems, and in a few cases four, while ordinary commercial glass generally contains five components, seven not being rare.

The equilibrium diagrams thus tell only part of the story. They define the temperature above which crystallization cannot occur, and indicate the compounds that will separate, if the glass is cooled to a lower temperature. They give no information on the rate at which devitrification will take place, nor at what temperature the crystallization rate will be at a minimum or maximum.

Principally through the work of Morey[1] considerable data is available on the liquidus temperatures of the three and four component systems of most interest in glass manufacture. However, very little data is available on crystallization velocity, and with the exception of the works of Zschimmer and Dietzel[2], and of Mullenseifen and Zschimmer[3], most of it is far too empirical in character to permit much application to practice.

By the very nature of the problem, the methods of measuring crystallization velocity must, like tests of chemical durability, be indirect tests, the interpretation of which requires correlation with actual practice. Accordingly, in planning research on crystallization velocity, it was decided to adopt a method, which, while admittedly experimental, would permit easy correlation with practical experience in any type of glass.

To achieve this objective it was decided that the required size of the sample must be small, that it must not require a great deal of preparation, and that the method must permit testing a fairly large number of samples at a time without requiring a great deal of attention. A modification of a method that had been employed elsewhere[4] was therefore decided upon.

Method and Apparatus

THE test method consists of subjecting small freshly fractured cubes of glass to a temperature of 800°C for varying periods of time, and determining the time required for appearance of the first signs of devitrification visible to the unaided eye.

In Morey's work, as previously stated, the devitrification temperature determined is the upper limiting value. In the work of Zschimmer and his associates, though the temperatures are lower, they are not fixed, both time and temperature varying. In our tests it was desired to keep the temperature constant while the time was increased to the point where devitrification took place. The temperature of 800°C was chosen because it is below the liquidus temperature of most glasses and because it is a fairly good average beween the upper and lower limits of the ordinary ranges of temperature at which glass is actually worked.

An electric furnace, shown in section in Fig. I, was made up especially for use in the tests. The core consisted of a stainless steel tube about ⅛" thick, 2½" in diameter and 16" long, around which a cast iron jacket about ½" thick had been cast. Over this jacket a thin coating of alundum cement was applied and allowed to dry before being wound non-inductively with nichrome wire. Another layer of alundum cement was applied over the winding, and the whole was mounted between end supports made of high temperature insulating brick. A sheet steel shell was then placed around the furnace and filled with insulating material. Transite plates were fitted over the insulating brick ends, and two strap-iron bands, which also formed the feet of the furnace, held the shell in place. Plugs, cut from high temperature insulating brick to fit the open ends of the tube, were used to close the furnace.

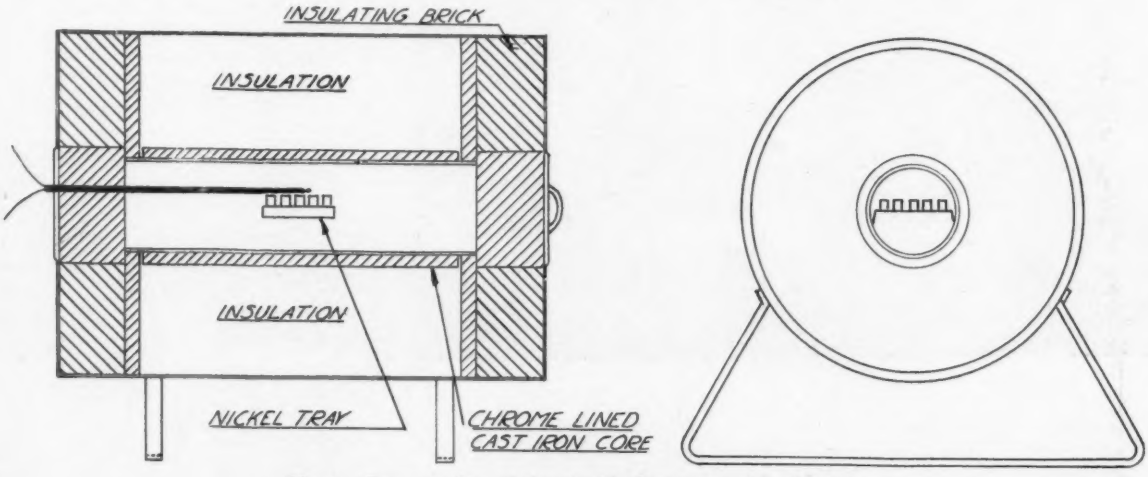


Fig. 1. Cross section of the electric furnace used in the tests.

Temperatures were measured by a bare chromel-alumel thermocouple extending to the center of the furnace and connected in the usual manner to a milli-voltmeter or potentiometer. The heavy iron core, and the fact that only the center 3" of the 16" length was used for the sample, insured a uniform temperature in the area occupied by the samples. The thermocouple, being about ½" above the samples and centered over them, acquired the same temperature as the samples within the limits of accuracy required.

The samples were placed in small porcelain crucibles measuring about ¼" high, ½" outside diameter, and about 1/16" wall thickness. A number of crucibles could be placed on sheet iron or nickel trays about 2½" wide and 3" long. A tray of samples, when in the furnace, rested on the sides of the stainless tube close to the horizontal diameter. About 20 samples could be run at a time.

In making the tests the temperature was held at 800 (± 5)°C by manual control. When a tray of samples was placed in the furnace the temperature was markedly affected, falling as much as 100°C as indicated by the thermocouple. This drop was due to the close proximity of the couple to the sample, but the furnace came back to temperature in five minutes or less because of the heat stored up in the heavy iron core.

Measurements on Some Glasses Containing Alumina

SEVERAL glasses containing alumina had been carefully prepared in lots of about 30 lbs. for another purpose, and from these, ten were selected for this test. All of the glasses were analyzed, and the compositions are given in Table I, the soda content being obtained in each case by difference. In these glasses Al_2O_3 is a substitution for SiO_2 in series one and two, and for CaO in series three.

TABLE I

Analyses of the glasses tested for Devitrification Time. Soda content is by difference. Iron is included with Al_2O_3 but is very small and quite constant in amount around 0.05 per cent.

Glass No.	Per Cent SiO_2	Per Cent R_2O_3	Per Cent CaO	Per Cent Na_2O	Devit. Time
1A	73.1	0.8	11.3	14.8	30 min.
1B	71.2	2.5	11.4	14.9	90 min.
1C	69.2	4.6	11.5	14.7	195 min.
1D	67.5	6.6	11.2	14.7	225 min.
2A	73.5	0.7	9.2	16.6	30 min.
2B	71.4	2.5	9.3	16.8	105 min.
2C	69.4	4.5	9.3	16.8	210 min.
2D	68.2	6.4	8.8	16.8	240 min.
3A	69.8	0.8	8.5	20.9	90 min.
3B	70.0	1.6	7.5	20.9	150 min.

The actual procedure in making the tests was as follows: Pieces, rough cubes about 5 mm. on an edge, were chipped from the slabs of glass and placed in the small crucibles. Special care was taken in every case to ensure getting a clean fresh fracture uppermost.

As a precaution against dust falling on the surface of the chipped pieces, the pieces were not prepared until the furnace was up to temperature (800°C). The samples were then placed in the furnace and held for 15 minutes at this temperature. Those glasses which did not devitrify were placed in the furnace for another

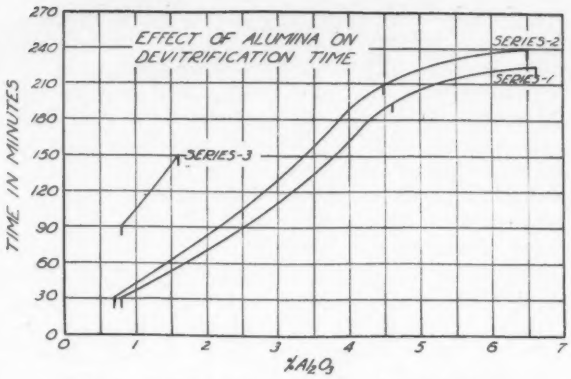


Fig. 2. Results of tests on experimental glass.

15 minute period. This process was repeated until visible devitrification had taken place. It was considered that a glass had devitrified when the first signs of filming of the surface appeared when the sample was examined under a strong light. In all cases fresh samples were chipped for each run, all glasses were run in duplicate, and any which did not check were run again.

Since the time interval in these tests was 15 minutes, there is an apparent uncertainty of about this amount in the actual time set forth as the "devitrification time," for each glass. That is, a glass might have been unaffected by 60 minutes of treatment but have shown definite devitrification in 75 minutes. The devitrification time, according to this system, would be taken as 75 minutes, and the uncertainty would be something less than 15 minutes.

However, the uncertainty in each measurement is identical so far as the interval is concerned, so that it is perfectly logical to take the minimum time actually found, as the "devitrification time" of the glass, rather than to have called it 67½ minutes, plus or minus 7½ minutes. It is admitted that devitrification can be noted under a microscope sooner than by the unaided eye, but this, also, is a purely relative matter, and the microscopic examination was dispensed with, in the interests of simplicity of the method.

While these tests were being made, seven commercial bottle glasses were run at the same time and in the same manner. Of these seven glasses, five devitrified in streaks, indicating that devitrification either was occurring in the cords first and not in the body of the glass, or vice versa. All of the commercial glasses devitrified in 90 minutes or less. The experimental glasses did not divitrify in streaks, but were fairly uniformly devitrified over the entire surface, indicating that they were more homogeneous than the average commercial glass. Moreover, in examining the samples for devitrification it was noted that the crystals in the high alumina glasses were much finer in size than those found in glasses with low alumina content.

The results of these tests on the experimental glasses

[1] This work covers a number of years and has been published in various journals. A good summary is available in "Modern Glass Practice" by S. R. Scholes, and contains references to the original publications.

[2] Journ. Soc. Glass Tech. 13, 84 ((1929).

[3] Glas. Tech. Ber. 9, 28 (1931).

[4] Private Communication.

are given in Table I and shown graphically in Fig. 2. The curves indicate that the substitution of alumina for silica, markedly affects the devitrification time.

Thus from the curve for series I it is seen that the substitution of one per cent Al_2O_3 for SiO_2, making the total Al_2O_3 equal to 1.8 per cent, doubles the time required to devitrify this glass at a temperature of 800°C. The effect of Al_2O_3 on devitrification time is slightly more pronounced for the glasses of lower lime and higher alkali content (Series 2).

In either series, the curves appoximate a straight line relation between the alumina content and devitrification time, up to about four per cent Al_2O_3. Beyond this point and up to 6.5 per cent Al_2O_3 the effect becomes progressively less.

ACKNOWLEDGEMENT

Further data obtained by the above method will be published in the future. In the meantime, acknowledgement is due the Consolidated Feldspar Corporation, Golding-Keene Company, North State Feldspar Corporation and Seaboard Feldspar Company, who sponsored a research project from which the above preliminary data were taken.

MARCH PLATE GLASS PRODUCTION UP

The Plate Glass Manufacturers of America report that their member companies produced 16,057,195 square feet of plate glass in March as compared to 13,856,937 square feet in February, and 16,531,950 square feet in March last year. This makes a total of 47,189,765 square feet produced in the first quarter of 1936.

TRANSMISSION OF LIGHT THROUGH WINDOW GLASSES

Department of Scientific and Industrial Research. Illumination Research. Technical Paper No. 18. Obtainable from H. M. Stationery Office, London. Price 30c.

Transmission data are given for 49 different glasses, including numerous configurated types as well as "window glasses". Measurements were made with incident light (1) normal to the glass (2) completely diffused (3) diffused but from a restricted zone. Transmissions of configurated glasses were ascertained with smooth side toward light and then in reversed position. There were also other variations in position.

A striking point is the very low transmission of some of the configurated glasses for diffused but restricted light as compared with normally incident light. In the case of one rather commonly used type, the respective figures were 48 per cent and 92 per cent. Incidentally, such a glass would generally be more useful if the reverse were true, that is, if transmission of sunlight were lower and if transmission of skylight were higher.

In reference to prismatic glasses the authors say: "The total transmission factor of such a glass is therefore of less importance than suitable distribution of the transmitted light, having regard to the particular conditions under which the glass is to be used." They might well have extended the scope of this comment to include other types.

Apart from data, there are photographs which show the extent to which the various configurated glasses, although transmitting light, prevent objects from being distinguished.

In an appendix is a report on the influence upon transmission of dirt accumulations under a specified condition in London.

As a source of mere transmission data, this paper is perhaps more complete in some respects than any other in print, but, since the correct choice of glass for any particular purpose is also contingent upon a number of other important factors, there remains the need for something which will serve as a practical guide.—L. T. S.

POLAROID—A NEW SOURCE OF POLARIZED LIGHT

The recent announcement by the Land-Wheelwright Laboratories, Boston, Mass., of the successful development of methods suitable for producing Polaroid, the new polarizing medium, on a large scale is of special interest to glass technologists. The substitution of Polaroid for the more expensive Nicol prism will enable the glass technologist to construct polariscopes capable of examining large fields and in addition will offer a relatively cheap source of polarized light that is practically unlimited as to area.

Polaroid consists of a lamination of two pieces of glass and a cellulose film in which is suspended many billions of microscopic organic crystals, all lying side by side and uniformly oriented. The resulting effect of this microscopic crystal arrangement is that the sheet of Polaroid acts optically as a single large polarizing crystal. Through proper alignment of sheets of Polaroid a single polarizing crystal of unlimited area may be constructed.

A polariscope using Polaroid is extremely simple in construction, all that is needed being a light source, a sheet of diffusing glass and two plates of Polaroid. The Polaroid plates are all set up a little distance apart and with their polarizing axes at right angles to each other. In this position no light is transmitted. Behind one of the Polaroid plates is the diffusing glass and the light source. The object to be tested for strain is then placed between the two Polaroid plates. If no strain is present the field will remain dark. With strain present, light will be transmitted and the field will appear light.

Apart from the field of glass technology, Polaroid offers interesting possibilities in eliminating headlight glare through its use in both the headlights and windshields of automobiles, in the production and viewing of the new three dimensional movies and in the production of colored illumination in store window trims and architectural ornaments by the use of cellophane in conjunction with Polaroid. Other applications in which polarized light is needed will find this new polarizing material cheaper, more flexible and as effective as the time honored Nicol prism.

KEG MAKERS HIT "KEGLINED" CANS

The misleading nature of the slogan "Keglined" used by the American Can Co. for cans for beer has been pointed out to the United States Patent Office in a petiion filed by he Associated Cooperage Industries of America. According to Thomas L. Gaukel, secretary of the Association, the keg manufacturers contend that the trade-mark is deceptive in that it tends to convey the impression that beer in cans is protected by a keg-like wooden lining. In fact, the inside of these beer cans is coated with lacquer.

It is also contended that the trade-mark gives the impression to the public that the cans contain draught beer similar to that in wooden kegs, whereas the cans actually contain pasteurized beer.

OWENS-ILLINOIS CONTINUES EXPANSION

In a recent letter to shareholders, the Board of Directors of the Owens-Illinois Glass Co., in addition to declaring a dividend of $1.25, divulged certain plans for future expansion. The earnings of the company totaled $7,923,-152.74 for the 12 months ending March 31, 1936 after deductions. These earnings are equivalent to $6.25 per share on the 1,267,000 common shares outstanding.

Expansion includes the purchase of 22 acres in Oakland, Cal., for the erection of a new factory for Owens-Illinois Pacific Coast Co. This plant is being constructed of glass blocks and glass insulating wool, two of the Company's products. The Streator, Ill., plant will be entirely re-built and re-equipped to afford facilities to customers in the Chicago district. The report also states that substantial sums should be spent to supplement equipment in the Company's other bottle plants.

The business of the Libbey Glass Co. in sales of thin blown tumblers has also increased and will warrant an addition to the factory building and warehouse as well as several additional machines.

Sales of products of the Industrial Materials Division have likewise increased to tax present productive capacity. Additional buildings and presses for manufacturing glass block are being provided at Muncie, Ind., and it is likely that some further enlargements for the production of glass wool for insulating purposes will be required next year. Additional units for the corrugated paper divisions at Streator, Gas City and other plants are to be installed. Additional warehouses and equipment will also be required for the can manufacturing plant serving the Pittsburgh area, and further expenditures will be made on the Baltimore can plant as customer's requirements indicate their need.

BUILDING INCREASE PREDICTED

Estimates gathered from various sources at random indicate that there should be a considerable increase in building activities during the coming months. The Dow Building Reports, for instance, point out that construction is going ahead in New York at a pace 67 per cent faster than it did last year.

In addition to this is a report from the Austin Co., Cleveland, Ohio, industrial and building engineers. George Bryant, Jr., general manager says, "Early estimates of a 50 per cent increase have been proven conservative by contracts already in hand and the increasing volume of inquiries from all parts of the country. At the present rate of sales, our 1936 material purchase will cover requirements on industrial buildings costing in excess of $10,000,000 and the equipment of these plants will probably involve other expenditures by the owners in excess of $20,000,000." Among the estimated requirements are 600,000 square feet of glass of various types.

Libbey-Owens-Ford Glass Co., Toledo, in a letter to their shareholders, state as follows, "Though building construction is still at a very low level, current figures being only 20 per cent of the average for the five year period preceding 1929, the recent trend has been upward."

Thus the prediction in the building field seems to be, "Weather clear, track fast."

DUTY ON BOTTLES AND JARS UPHELD

Duty of 75 and 60 per cent assessed by New York customs collectors on glass bottles and jars to be used chiefly as containers of powder, perfume or candy, although not ordinarily sold as containers for such merchandise, has been upheld by the Customs Court. These were found not to come under the classification for bottles and jars used for holding or transporting merchandise. An alternative claim for free entry was denied on a finding that the etching was the work of industrial rather than fine art.

EXTEND CZECH GLASS CARTEL TO 1940

The Prague office of the Department of Commerce reports that the local cartel agreement of the Czechoslovak plate and sheet glass manufacturers has been extended to December 31, 1940. This agreement, which is operated through the Prodejni Sdruzebi Ceskych Tabularen A.S., regulates production, domestic and foreign sales, and prices.

An enamel symposium will be held in the Ceramics Building at the University of Illinois in Urbana on May 9. Papers will be followed by general discussions, and everyone interested in enamels is urged to attend.

The Allegheny recently overflowed its banks and deposited several feet of ice along the roadway outside the plant of the Wightman Bottle and Glass Co. This photo was supplied by Walter Thieser of the Pittsburgh Post-Gazette.

GLASS CONTAINER ASSOCIATION TO MEET IN WHITE SULPHUR SPRINGS

The Board of Directors have selected White Sulphur Springs, W. Va., for the annual meeting of the Glass Container Association, to be held on May 6, 7 and 8. The tentative program is as follows: Wednesday, May 6, Board of Directors meeting and Cap and Closure Division meeting; Thursday, May 7, meeting of entire membership followed by a golf tournament and banquet; Friday, May 8, Glass Division meeting. As The GLASS INDUSTRY goes to press, committees are being appointed and details of the entire program are being worked out. In the meantime, however, it is suggested that reservations be made directly with the Hotel Greenbrier in White Sulphur Springs.

INTERNATIONAL CONGRESS ON GLASS TO BE HELD IN ENGLAND IN JULY

At the invitation of the Society of Glass Technology, the Second International Congress on Glass will be held in England from Thursday, July 2, to Saturday, July 11. The meetings will be held for the most part in London with headquarters at the Institution of Mechanical Engineers, Storey's Gate, Westminster, and the remainder in Sheffield, in the University Buildings.

Dr. J. C. Hostetter of the Corning Glass Works, Corning, N. Y., will act as secretary for the United States and Dr. S. R. Scholes of the New York State College of Ceramics, Alfred, N. Y., will represent The GLASS INDUSTRY at the convention.

Actual arrangements for the Congress will be in the hands of Professor W. E. S. Turner, The Society of Glass Technology, Darnall Road, Sheffield, 9, England.

DR. LITTLETON PASSES THE CRISIS

Dr. J. T. Littleton of the Corning Glass Works, who was seriously injured in an automobile accident on April 11, is reported to have passed the crisis of his illness and to be on the way to recovery. Although infection has been arrested, it has not yet been possible to operate for internal injuries. Dr. Littleton was hurt while returning to Corning from Bethlehem, Pa., where he had just addressed the American Institute of Electrical Engineers. Among his injuries were a fractured pelvis and a broken knee cap as well as internal injuries. As The GLASS INDUSTRY goes to press, it is happy to report that Dr. Littleton is regaining his strength and to wish him an early recovery.

DOCTOR HOSTETTER'S SON TO WED

Mr. and Mrs. John Humphrey Bagby of Centralia, Mo., have announced the marriage of their daughter, Dorothy, to John R. Hostetter. Mr. Hostetter is a son of Dr. J. C. Hostetter of the Corning Glass Works, Corning, N. Y., and a contributor of many interesting photographs to THE GLASS INDUSTRY.

SUTCLIFFE VISITS AMERICAN PLANTS

T. C. Sutcliffe of J. W. Sutcliffe & Co., London, England, bottle manufacturers, has returned home after a stay of some three weeks in the United States. Although Mr. Sutcliffe made his headquarters at the Hotel Waldorf-Astoria in New York, he visited many cap and glass manufacturers in Baltimore, Chicago, and other parts of the United States, as well as Canada.

PITTSBURGH PLATE INSTALLS UNUSUAL POWER UNIT

Manufacturers who suffered loss or shortage of power in the recent floods in the Pittsburgh area and in New York state, will appreciate the motives which impelled the Pittsburgh Plate Glass Co. to install an automatic unit to take over the entire power load of their Mt. Vernon, Ohio, plant in 15 seconds. A unique, fully automatic starting system was designed and installed on a 275 H. P. Cooper-Bessemer gas engine. In case of purchased power failure, this auxiliary unit takes over the full power load immediately whether any of the operating force is in the power room at the time or not.

A relay device operated by a 32-volt battery turns on the ignition, trips open the gas and water valves, and cranks the engine, which kicks off in two or three seconds. Another four or five seconds brings it up to full speed. And then, after correct voltage is assured, a second relay hooks it onto the load. In order to avoid power loss for even a second, a 230-volt, 20 kw. direct-current storage battery takes care of essential load requirements temporarily until the engine starts.

The automatic power unit consists of a 275 H. P., four-cycle, Type EN-6 Cooper-Bessemer gas engine, direct-connected to a 240-volt, 175 k.w. generator and a V-belt-driven exciter. Instant starting—even faster than a good automobile engine—is assured by exact and scientific regulation of gas and air, and by operation at constant atmospheric pressure.

It is not generally possible to purchase ready-designed automatic equipment such as this. In designing it, Pittsburgh Plate engineers spent only a small sum for labor and materials. Standard equipment was used almost entirely. A regular gear motor was taken out of stock. Of the half-dozen relays, three were built from standard parts and the others were conventional relays.

The automatic power unit is tested weekly, going through the full series of operations, even carrying a test load. Purchased power failed once since the installation; and the standby unit had the correct voltage on the switchboard within fifteen seconds.

In addition to the automatic starting equipment, many other unusual devices were installed on the engine. These include: automatic throttle control, thermostatic cut-out for excessive cooling-water temperatures, switchboard lights to show that automatic gas and water valves are open, automatic over-speed switch. Another feature is an alarm bell that rings continually from the time of purchased-power failure until the electrician checks over the engine to see that everything is operating satisfactorily.

H. F. Hitner and H. W. Gardner are the Pittsburgh Plate Glass Co. electrical engineers responsible for the installation. Charles C. Dice is the assistant master mechanic and chief electrician of the Mt. Vernon plant. A. C. Oakes is the master mechanic, and John Thompson the construction electrician.

Thomas Wardley of the British-Hartford-Fairmont Syndicate of England is at present visiting various American glass factories. After attending the American Ceramic Society convention in Columbus, Mr. Wardley spent some time at the Lynch Corporation, Anderson, Ind., and the Hartford-Empire Co. in Hartford, Conn.

SANDWICH GLASS

By ALEXANDER SILVERMAN[1]

Head of the Department of Chemistry, University of Pittsburgh

The preceding articles on Sandwich Glass have appeared as follows: I. Crystal Glass in the February GLASS INDUSTRY*; II. Opal and Alabaster Glasses in the March number; III. Ruby Glass in April. As in the preceding article, "K" will indicate batches from the records of William E. Kern, and "F" batches from the records of George L. Fessenden. The Roman numerals after the Fessenden numbers indicate Part I and Part II respectively of his records.*

The reader will recall the wide and varied knowledge of glass making displayed in batches previously discussed. This is also true of the amber, yellow, and green batches which the present article covers. As stated a number of times, it seems quite remarkable that the glass makers at Sandwich should have been so versatile.—The Editor.

IN HIS miscellaneous notes Fessenden states, "Coke in powder will give a good amber, provided neither arsenic, nor nitrate of soda or nitrate of potash, or lead enter into the composition. Beech bark dried and pulverized will answer the same purpose. Cream of tartar added in small quantities and wine lees will aid this color." No general notes are found in Kern's records.

K 7A. George L. Fessenden Amber:

Sand	300 lb.
Ash pearl	120 lb.
Lime	80 lb.
Birch bark	1 lb.
Nut-gall	5 oz.

"To make dark color, increase 2 lb. bark and 10 oz. nut-gall."

It must have been difficult to grind the birch bark. Nutgall is the gall from young twigs of certain plants which grow in Syria and Turkey. The accumulation on the twigs is caused by eggs which are deposited by insects. The excretion contains 2 to 4 per cent of gallic acid and 50 to 60 per cent of tannic acid. The remainder consists of other acids, mucilage, sugar, and resin. Like birch and beech bark, flour, sugar, and other organic materials, nutgall chars to carbon, which is the coloring agent. Sulfur or sulfates are usually employed with the carbon or organic compound to produce the amber color, which corresponds to that of alkali polysulfides. It is likely that the crude pearl ash which was employed contained sufficient sulfate as an impurity to produce the effect.

K 7B. Dark Amber:

Sand	135 lb.
Soda ash	60 lb.
Chalk	35 lb.
Coke	30 oz.

Coke is employed to produce the amber color. It is surprising that this material should have been used so long ago. In this batch the soda ash was probably Le Blanc, which contains sulfates as an impurity.

[1] Contribution No. 316 from the Department of Chemistry, University of Pittsburgh.

At the extreme right is the counting house of the old Sandwich glass works.

K 8B. John Doherty Amber:

Sand	100 lb.
Soda ash	52 lb.
Lime eastern	20 lb.
Plumbago	1 lb.
Manganese	1 lb.

Plumbago is employed for the first time. It is also known as black lead or graphite. The manganese probably also assisted in producing the color and afforded a slightly rose tone.

K 38A. Kern's Amber:

Lead batch	450 lb.
Crocus martus	38 lb.
Manganese	18 lb.
Black antimony	1 lb.
Amber cullet	300 lb.

The particular batch employed is not indicated. This frequently occurs in Kern's records. Crocus Martus is red oxide of iron or ferric oxide. Black antimony is the black sulfide. The amber color in this case was probably due to the diluted and iron lead sulfides which formed in the melt.

K 39B. Amber:

Batch	100 lb.
Crocus martus	4 lb.
Manganese	2 lb.

Here there is not even an indication of the type of batch which was used.

K 40. Kern's Amber:

Sand	225 lb.
Ash	135 lb.
Borax	30 lb.
Antimony	5 lb.

"When well melted add 300 grains of coal dust and stir well."

It is incredible that this batch should have produced a satisfactory glass as it contains neither lime, nor an oxide of lead, and should have crumbled on exposure to moist air through hydrolysis. "Black" antimony must have been employed to produce the amber color.

F 32-I. Common Amber:

Sand	135 lb.
Soda ash 52 degrees	50 lb.
Chalk or lime	45 lb.
Coke in very fine powder	625 gr.

"This is very light If you wish to darken your color add Coke. Be sure not to admit into this color either manganese, arsenic or nitrate of soda or you will lose your color entirely."

"Soda Ash 52 degrees" probably means 52 per cent Le Blanc soda, in contrast to the 58 per cent alkali now employed. Why equal quantities of chalk or lime should have been employed is a puzzle. If the lime was burnt lime, only 56 per cent as much as chalk should have been employed. In Fessenden's note it is clear that nitrate of soda would have destroyed the color. Even a small amount of manganese dioxide might have done so. The arsenic trioxide should not destroy the color.

F 47-II. Amber:

Sand	135 lb.
Soda ash 52 degrees	60 lb.
Chalk	35 lb.
Coke in powder	22 oz.

F 48-II. Darker Amber for brown work:

Sand	135 lb.
Soda ash 52 degrees	60 lb.
Chalk	35 lb.
Coke in powder	30 oz.

As already intimated, the sulfate in batch 47 and 48 was probably an impurity in the soda ash.

The amber batches at Sandwich include types in which the color was due to sulfide of iron or sulfide of lead, although the Sandwich glass makers may not have known that they formed during the melt. Naturally, the more modern lead selenide ambers were not known.

NO YELLOW batches are recorded in Kern's book. The following are all taken from Fessenden's records. In his miscellaneous notes Fessenden states, "Antimony regulus is useful in making straw colors and yellows. The same remark applies to the oxide of antimony."

F 29-I. Good Canary:

Sand	250 lb.
Soda ash 52 degrees	50 lb.
Potasse	50 lb.
Chalk	90 lb.
Nitrate of soda	10 lb.
Arsenic	1 lb. 8 oz.
Oxide of uranium	1 lb. 4 oz.

Note that the Sandwich glass makers are here fully conversant with the use of uranium oxide for the production of a fluorescent greenish yellow.

F 47-I. Dycloroide Canary:

Sand	225 lb.
Marble	50 lb.
Lead	30 lb.
Arsenic	5 lb.
Nitrate soda	110 lb.
Soda ash	10 lb.
Boracic acid	10 lb.
Uranium	2 lb.

"Dycloroide" probably means dichroic or the displaying of two different colors depending on the angle of the light upon the colored object. As uranium oxide is employed, the glass would look yellow or green according to this angle. The batch is unusual through its very high niter content and low soda, and also through the presence of boracic acid.

F 33-I. Common Yellow for Flint Metal Containing Lead:

Flint	288 lb.
Red ochre	6 lb.
Manganese	1 lb.
Antimony regulus	1 lb.

The lead batch is not specified. "Red Ochre" is probably one of the ocherous mineral deposits which contain from 47 to 63 per cent of ferric oxide, with calcium carbonate up to 21 per cent, and water or volatile organic material together averaging about 25 per cent. Regulus of antimony is the element.

F 38-II. Dycloroide Yellow Best Quality:

Sand	270 lb.
Soda ash 52° English	45 lb.
Rough potash	45 lb.
Chalk	90 lb.
Nitrate of potash	10 lb.
Uranium	1 lb. 12 oz.

It is uncertain whether "rough potash" means coarse pearl ash or crude. The specification of English as the "soda ash, 52°" appears for the first time. It is likely that all of the Le Blanc soda ash used at Sandwich was imported from England.

F 39-II. Dycloroide Yellow common quality:

Sand	270 lb.
Soda ash 52°	90 lb.
Chalk	90 lb.
Nitrate of soda	10 lb.
Uranium	1 lb. 8 oz.

F 37-I. Lemon:

Sand	240 lb.
Potasse	100 lb.
Baryta pure precip. carb.	4 lb.
Plaster of Paris	6 lb.
Fluorspar	14 lb.
Arsenic	2 lb.
Uranium	2 lb.

"You will observe that I have a little less plaster than in the first receipts I gave you and that the fluorspar is rather increased. This is not material, but I find that the plaster is rather apt when in excess to make the metal specky except when founded in a very hot furnace."

This section of Fessenden's records deals with alabaster glasses in which the use of sulfates like plaster of Paris, was discussed in the article on opal and alabaster glass. His own note is the first comment on the effect of a large amount of sulfate. Alabaster glasses are characterized by small white specks when chlorides and sulfates are employed, and the sulfates produce elliptical milky blisters when used in excess. The "very hot furnace" may have decomposed the excess plaster of Paris. The so-called "salt water" forms when much more than 2 per cent of chloride or sulfate is present in the glass, and is either ladled, or reduced by throwing straw into the pot.

F 46B-I. Yellow Enamel:

Sand	80 lb.
Lead	80 lb.
Salt petre	13 lb.
Ash	10 lb.
Putty Powder	8 lb.
Arsenic	7 lb.
Bones	2 lb.
Oxide uranium	2 lb. 3 oz.

The putty powder (stannic oxide), arsenic trioxide, and bone ash should produce an intense opacity in this soft glass or enamel.

Silver yellows are not included in the Sandwich batches, although a silver compound was employed in one of the opal batches published in the second article of this series. The cadmium sulfide and the titanium and cerium oxide yellows had not been discovered.

GREEN GLASSES

K 18: Green:

Batch	100 lb.
Copper	1 lb.
Iron	14 oz.
Bicarb. potash	4 oz.
Crocus martus	8 oz.
Uranium	4 oz.

Added 7 oz. crome and 4 oz. uranium

The batch is not specified. It is probably a lead glass. This is the first mention of potassium bicarbonate. Reference to the metals, copper, iron, and uranium, undoubtedly means the oxides. "Crome" may mean chrome green, which is chromic oxide (Cr_2O_3), or chrome yellow, which is lead chromate ($PbCrO_4$).

K 33A. Wm. E. Kern—Olive Green:

Batch	7½ lb.
Green chrome	1 oz.
Black oxide copper	½ oz.
Crocus martus	1 oz.
Uranium	1 oz.

This batch implies that "crome" was chrome green.

K 33B:

Batch	200 lb.
Oxide copper	8 lb.
Oxide iron	3 lb.
Uranium	1 lb.

K 34A. Good Olive Green:

Batch	7 lb.
Green chrome	2 oz.
Copper	1½ oz.
Crocus martus	1 oz.
Uranium	½ oz.

K 34B:

Batch	3 lb.
Oxide copper	3 oz.
Oxide iron	1¼ oz.
Uranium	¼ oz.

The black oxide of copper, cupric oxide (CuO) and the red oxide of iron, ferric oxide (Fe_2O_3) are usually employed.

K 35B. Green from Book:

Batch	200 lb.
Copper	11 lb.
Iron	4 lb.
Uranium	1¼ lb.

K 36A. Green:

Batch	300 lb.
Copper	16 lb.
Iron	6½ lb.
Uranium	1¼ oz.

K 38B. Kern's Bronze Green, Dark:

Batch	1000 lb.
Cullet	600 lb.
Green chrome	4 lb.
Copper scales	1 lb.
Crocus martus	2 lb.
Uranium	4 lb.

Copper scale is a mixture of the oxides of copper.

K 39A. Light Bronze:

Batch (1000)	800 lb.
Cullet	600 lb.
Chrome (1½)	2 lb.
Copper	½ lb.
Crocus martus (12 oz.)	1 lb.
Uranium (1¼)	2 lb.

The amounts indicated in parentheses are evidently intended for a modification of the batch.

K 39C. Green:

Batch	300 lb.
Cullet	500 lb.
Chrome	12 oz.
Copper	4 oz.
Crocus martus	5 oz.
Uranium	8 oz.

It is regrettable that the Kern greens do not specify the crystal batches to which the coloring agents are added. In the Fessenden batches which follow, the flint batch is usually specified by number or the entire batch is given in detail.

F 7-I. Common Dychroide Green for Pressed Work:

Flint blacks	1200 lb.
Batch 62	250 lb.
Oxide of uranium	2 lb. 8 oz.
Oxide of copper	1 lb. 8 oz.

"You may use any Crysopras cullet you have in this, it will aid the color."

"Flint blacks" probably refers to a flint cullet in which nickel oxide was used as a decolorizer. This cullet has a dark appearance. "Dychroide" probably means two-color effect due to the presence of a uranium compound. Batch No. F 62-II follows:

Good Press Metal English:

Sand	1200 lb.
Red lead	500 lb.
Bicarbonate of soda	275 lb.
Refined ashes	75 lb.
Nitrate of soda refined	100 lb.
Chalk	100 lb.
Arsenic	3 lb.
Manganese	1 lb. 6 oz.
Cobalt	14 gr.

F 30-I. Good Pomona Green:

Sand	250 lb.
Soda ash 52 degrees	50 lb.
Potasse	50 lb.
Chalk	90 lb.
Nitrate of soda	10 lb.
Arsenic	1 lb. 8 oz.
Oxide of uranium	1 lb. 4 oz.
Black oxide of copper	10 oz.

"For the best description of Canary or Pomona Green use all ash in place of Soda, and Nitrate of Potasse in place of Nitrate of Soda."

Pomona was the goddess of fruits. The color may mean apple green. The note which follows this batch is not clear unless Fessenden intends using all pearl ash instead of part pearl ash and part soda ash.

F 31-I. Common Green for Chimnies:

Flint batch and blacks	600 lb.
Oxide of copper black	10 lb.
Oxide of iron common	5 lb.

Since F 62-II was previously specified as the crystal

batch which serves as a foundation for green, this is probably used again. "Blacks" probably means flint blacks mentioned after F 7-I. In Fessenden's miscellaneous notes we find: "For green, common oxide of iron will do very well, or even iron scales. These give a yellow tint to green glass."

F 40-II. Dycloroide Green (Pomona) best quality:

Sand	270 lb.
Soda ash 52°	45 lb.
Rough potash	45 lb.
Chalk	90 lb.
Black oxide of copper	6 oz.
Uranium	1 lb. 8 oz.

F 41-II. Common Pomona:

Sand	270 lb.
Soda ash 52 degrees	90 lb.
Chalk	90 lb.
Nitrate of soda	10 lb.
Sulphate of copper	12 oz.
Uranium	1 lb. 8 oz.

This batch is cheaper than F 40-II as it does not contain potash. Copper sulfate was probably cheaper than the oxide at the time.

F 42-II. Another Cheaper Pomona:

Sand	270 lb.
Soda ash 52 degrees	90 lb.
Chalk	90 lb.
Nitrate of Potash	10 lb.
Sulphate of Copper	12 oz.
Uranium	1 lb.
Chromate of Potash	8 oz.

This batch is still cheaper than F 41-II as part of the color depends on potassium chromate instead of uranium oxide.

F 45-II. Chinese Green:

Sand	270 lb.
Soda ash 52 degrees	60 lb.
Rough potash	30 lb.
Chalk	90 lb.
Sulphate of Copper	1 lb. 4 oz.
Uranium	12 oz.
Chromate of potash	8 oz.
Nitrate of soda	10 lb.

F 46-II. Another Cheaper Chinese Green:

Sand	270 lb.
Soda ash 52 degrees	90 lb.
Chalk	90 lb.
Nitrate of soda	10 lb.
Sulphate of copper	1 lb. 8 oz.
Uranium	8 oz.
Chromate of potash	8 oz.

The cost is again cut down by using all soda ash instead of part potash, and by reducing the amount of uranium oxide. "Chinese green" is a light bluish green.

Demi crystal No. 68 follows:

F 51-II. Common Green:

Demi crystal No. 68	100 lb.
Copper scales	3 lb.
Iron scales	1 lb.

F 68-II. Flints without Lead:

Sand	270 lb.
Soda ash 52 degrees	85 lb.
Chalk	90 lb.
Nitrate of soda	8 lb.
Arsenic	1 lb.
Blue manganese	1 lb.
Manganese pure	12 oz.

It will be recalled that blue manganese is a variety of pyrolusite which has a bluish cast.

F 52-II. Another Green:

Demi crystal No. 68	150 lb.
Oxide of copper black	3 lb.
Iron oxide colcotha	1 lb. 8 oz.

In the old process for manufacturing fuming sulfuric acid from pyrites (FeS_2), this was roasted in air to form a basic ferric sulfate ($Fe_2S_2O_9$); the latter on heating yielded a ferric oxide (Fe_2O_3), called Colcothar.

F 53-II. Another common green, Close Imitation of the Antique:

Demi crystal No. 68	150 lb.
Chromate of potash	1 lb.
Chromate of iron	1 lb.

This is the first reference to chromate of iron, in fact the author has never heard of its use except in this case.

F 58-II. Green for Signals, etc.:

Common Flint No. 67 or	
Demi crystal No. 68	100 lb.
Brass dust	4 lb.
Red oxide of iron	1 lb. 8 oz.
Iron scales	4 oz.

It is interesting to see that pressed lenses for railroad signals were made at Sandwich. This is the first record of glass that was manufactured for the purpose. Brass is an alloy of copper and zinc. Crystal batch No. 68 has already been given. No. 67 follows:

F 67-II. Ordinary French Crystal:

Sand	300 lb.
Red lead	100 lb.
Bicarbonate of soda	75 lb.
Refined ashes	20 lb.
Nitrate of soda	25 lb.
Chalk	25 lb.
Arsenic	8 oz.
Blue manganese	15 oz.
Manganese pure	8 oz.

GREEN BATCHES FOR CASING OR FLASHING

K 31A. James D. Lloyd's Green for coating:

Best batch	200 lb.
Lead extra	6 lb.
Ash extra	4 lb.
Salt petre extra	5 lb.
Black ox. copper	14 lb.
Crocus martus	7½ lb.
Iron scales	12 oz.

The crystal batch is not given by number. The "extras" are probably additions to the crystal batch.

K 31B:

Sand	400 lb.
Lead	300 lb.
P. ash	120 lb.
Salt petre	40 lb.
Green chrome	24 lb.
Oxide of copper	14 lb.

"Coating" probably means flashing for the green was usually combined with an opal glass to manufacture lamp shades. These are the only green batches for casing which are mentioned in Kern's records.

F 16-I. Good Green for Casing:

Sand	150 lb.
Minium	100 lb.
Potasse	45 lb.
Black oxide of copper	14 lb.
Red oxide of iron	5 lb.
Uranium	1 lb.

F 28-I. Green for Casing, Nov. 6, 1866:

Sand	150 lb.
Minium	100 lb.
Potasse	40 lb.
Salt petre	5 lb.
Black oxide of copper	21 lb.
Red oxide of iron	7 lb. 8 oz.
Oxide of uranium	7 lb. 8 oz.
Arsenic	8 oz.

"This is the same as No. 16 but darker, containing 50% more color.

F 44-I. Coating Green:

Sand	65 lb.
Lead	65 lb.
Salt petre	25 lb.
Ash	20 lb.
Red or black oxide copper	12 lb.
Black oxide iron	5 lb.
Green chrome	5 lb.

Black oxide of iron is the magnetic oxide (Fe_3O_4).

F 29-II. Casing Green:

Sand	60 lb.
Red lead	40 lb.
Potash	18 lb.
Black oxide of copper	6 lb.
Oxide of iron	2 lb.
Uranium	7 oz.

F 30-II. Another Green for Casing:

Sand	60 lb.
Red lead	40 lb.
Potash	18 lb.
Black oxide of copper	6 lb.
Bichromate of potash	2 lb.
Oxide of iron	8 oz.

This is the first mention of bichromate of potash or potassium bichromate ($K_2Cr_2O_7$) among the green batches. It has the advantage of providing a fine distribution of chromium at a fairly low cost; the cheaper sodium dichromate is now used. When chrome green or the trioxide is employed, it is rather infusible and does not flux readily, so that dark streaks occur at times.

F 12-II. Light Green for Opal Cased Shades and Reflectors:

Sand	250 lb.
Red lead	50 lb.
Potash	100 lb.
Chromate of potash	2 lb.
Uranium	2 lb.
Black oxide of copper	8 oz.

On the basis of batch numbers this is the first reference to chromate of potash, or potassium chromate (K_2CrO_4). This is the only green casing batch which is directly specified for opal-cased ware. There is unfortunately no specific reference to the opal batch which is to be employed. It is probably F 27-II, which appeared in the second article on Sandwich glass.

Green Alabasters

ALTHOUGH a large variety of green alabaster glasses was made at Sandwich, no batches are included in Kern's records. When the writer visited Cape Cod in the fall of 1923 he went to the old Sandwich site and dug into the cullet pile which had been buried. The specimens obtained included not only the regular alabasters discussed in the second installment, but the greens for which batches follow, some pale amethysts, and a variety of light blues.

F 35-I. Chrysopras:

Sand	240 lb.
Potasse	100 lb.
Pure precip. carb. baryta	4 lb.
Plaster of Paris	6 lb.
Fluorspar	14 lb.
Arsenic	2 lb.
Oxide of uranium	2 lb. 12 oz.
Black oxide of copper	19 oz.

"Chrysopras" is a green variety of the mineral chalcedony which is sometimes used as a gem. It is interesting to note that the Sandwich alabasters contained barium carbonate, plaster of paris, and fluorspar. As stated in the installment on opal and alabaster glasses, the first two substances have been the subjects of comparatively recent patents.

F 38-I. Pale Green Alabaster:

Sand	240 lb.
Potasse	100 lb.
Baryta pure precip. carb.	4 lb.
Plaster of Paris	6 lb.
Fluorspar	14 lb.
Uranium	19 oz.
Sulphate of copper	10 oz. 240 gr.

Here plaster of Paris or calcium sulfate ($2CaSO_4 \cdot H_2O$) and copper sulfate ($CuSO_4 \cdot 5H_2O$) are the sulfates employed to produce the alabaster effect.

F 16-II. Alabaster Chrysopras:

Sand	180 lb.
Potash	75 lb.
Baryta pure carb. recip.	3 lb.
Plaster of Paris	5 lb.
Fluorspar	10 lb.
Uranium	1 lb. 12 oz.
Black oxide of copper	9 oz.

F 21-II. A Pale Green Alabaster:

Sand	180 lb.
Potash	75 lb.
Baryta pure precip. carb.	3 lb.
Plaster of Paris	5 lb.
Fluorspar	10 lb.
Uranium	14 oz.
Sulphate of copper	8 oz.

F 71-II. Malachite:

Take of Casing Green Cullet	50 lb.
Flux this then add opal cullet No. —	10 lb.
Red oxide of iron	1 lb.

"Thow this on the fluxed green cullet and stir around with a bar and work in about half an hour."

"Malachite" is a natural mineral $Cu_2(OH)_2CO_3$. It has a variegated bluish green color. This effect was probably produced by mixing various types of cullet and adding a little ferric oxide to the mixture before stirring.

No records exist of tellurium and praesodymium greens, as these were not known at the time.

The next installment will cover the manufacture of blue, amethyst, and black glasses.

GLASS RODS DECLARED DUTIABLE

As a result of a decision by the United States Court of Customs and Patent Appeals, glass rods of all kinds were held dutiable. The opinion, given in the case of United States vs. Meadows, Wye & Co. (T.D. 48143), would seem to indicate an intention of Congress to remove glass rods from other parts of the tariff acts and carry them within the scope of paragraph 218 (b) of the Tariff Act of 1930.

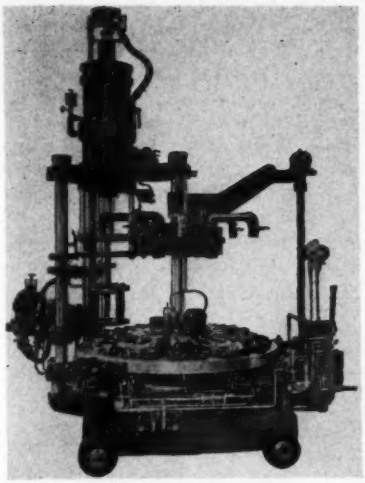
CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks	Per 100 lb.	...	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.13½
52% and 48%	lb.	.10	.10-.11½
Nitric (HNO_3) 130 lb. carboy ext.	Per 100 lb.	...	5.50
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	...
Tartaric	lb.	... Po. or Gr. / Cry.	.25 / .25½
Aluminum hydrate (Al (OH)₃)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.0515	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.14½
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¾
Antimonate of Sodium	lb.	.12¾	.13¾
Antimony oxide (Sb_2O_3)	lb.	...	.13¾
Antimony sulphide (Sb_2S_3)	lb.	...	.13
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04-.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite)			
90%, 99% through 200 mesh	ton	40.00	45.00
90% through 100 mesh	ton	37.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.049	.05½
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.07¾
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
(Commercial, 25% Selenium)	lb.	16.00	.90
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash	lb.	.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	...	...
Granulated	In bags, lb.	.022	.0245-.027
Powdered	In bags, lb.	.0245	.027-.0295
Boric acid (H_3BO_3) granulated	In bags, lb.	.05	.0525-.055
Cadmium sulphide (CdS)—	lb.	...	1.00-1.10
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Chromite	lb.	...	.0215
Cerium hydrate			
100 lb. drums and 600 lb. barrels	lb.	...	.65
Chrome Oxide Green, 400 lb. bbls.	lb.	.17	.215-.25
Cobalt oxide (Co_3O_4)			
In bbls.	lb	...	1.29
In 10 lb. tins	lb.	...	1.39
Copper oxide			
Red (Cu_2O)	lb.	...	.20
Black (CuO)	lb.	...	.15
Black prepared	lb.	...	.22
Cryolite ($Na_3Al F_6$) Natural Greenland			
(Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08	.09
Epsom salts ($MgSO_4$) (imported) technical	Per 100 lb.	...	2.30
Feldspar—			
20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%)			
Bulk, carloads, f. o. b. mines	ton	31.50	...
In bags	ton	33.10	38.00-40.60
Formaldehyde, bbls.	lb.	...	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide—			
Red (Fe_2O_3)	lb.	...	.0425
Black ($Fe3O_4$)	lb.	.04½	..
Iron chromate	lb.	...	.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	..
English, lump, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.0710	...
In 5 Ton lots	lb.	...	.075
Less than 5 Tons	lb.	...	08

		Carlots	Less Carlots
Lime—			
Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.25	2.25
Limestone ($CaCO_3$)	ton	1.75	...
Litharge (PbO) (New York Prices)	lb.	.0610	...
In 5 Ton lots	lb.		.065
Less than 5 Tons	lb.		.07
Magnesium carbonate ($MgCO_3$)	lb.	.0610	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.0265
Manganese, Black Oxide			
In Paper bags	ton	50.00	52.50-55.00
In Burlap bags	ton	51.50	54.00-56.50
In Casks	ton	53.00	55.50-58.00
Neodymidm oxalate, 50 lb. drums	lb.	...	5.00
Nickel oxide (Ni_2O_3), black	lb.	...	.35-.40
Nickel monoxide (NiO), green	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)—			
Crystals	lb.	...	.09
Powdered	lb.	...	.09½
Potassium carbonate			
Calcined (K_2CO_3) 96-98%	lb.	.06⅞	.07⅜
Hydrated 80-85%	lb.	.06	.06¼-.06⅜
Potassium Chromate (K_2CrO_4) 100 lb. kegs	lb.	...	.27
Potassium hydrate (KOH) (caustic potash)	lb.	.06¼-.06½	.08-.08½
Potassium nitrate (KNO_3) (gran.)	lb.	.0545	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	...	.19
Powder blue	lb.	...	.17½-.18¾
Rare earth hydrate			
100 lb. drums	lb.	...	.35
325 lb. barrels	lb.	...	.30
Rochelle salts, bbls.	lb.	...	.12½
Rouge	lb.	... Po. or Gr. / Cry.	.13½
Rutile (TiO_2) powdered, 95%	lb.	.10-.12	.13-.15
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se) In 100 lb. lots	lb.	...	2.00
In lesser quantities	lb.	...	2.10
Silver nitrate ($AgNO_3$) . (100 oz. bot.) per oz.		...	.39
Soda ash (Na_2CO_3) dense, 58%—			
Bulk	Flat Per 100 lb.	1.10	...
In barrels	Per 100 lb.	1.50	...
In bags	Per 100 lb.	1.25	...
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06½	.07
Sodium chromate ($Na_2CrO_4 10H_2O$)	lb.	...	.08½
Sodium fluosilicate (Na_2SiF_6)	lb.	.06½	.07
Sodium hydrate (NaOH) (caustic soda)			
Flake	Per 100 lb.	3.00	...
Solid	Per 100 lb.	2.60	...
Sodium nitrate ($NaNO_3$)—			
Refined (gran.) in bbls.	Per 100 lb.	...	2.00-2.25
95% and 97%			
Bulk	Per 100 lb.	1.225	...
200 lb bags		1.29	1.34
100 lb. bags		1.325	1.375
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.	...	1.50 1.55
Yellow	lb.	...	1.50-1.55
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)—			
Flowers, in bbls.	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls.	Per 100 lb.	2.90	3.25-3.65
Tin chloride ($SnCl_2$) (crystals) . in bbls.	lb.	...	.36
Tin oxide (SnO_2) in bbls.	lb.	...	.51
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	2.25
Yellow orange	lb.	...	1.50
Zinc oxide (ZnO)			
American process, Bags	lb.	.05	.05¼
White Seal, 150 lb. bbls.	lb.	.06¾	.07
Green Seal bags	lb.	.06	.06¼
Red Seal, bags	lb.	.05½	.05¾
Zircon			
Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude. Gran. (Milled .005-.02c higher)		.03½	.04-.05

EQUIPMENT AND SUPPLIES



LYNCH CORPORATION'S NEW GENEVA DRIVEN PRESS

The Lynch Corporation, Anderson, Ind., advise that their model MPLS offers many improvements never before combined in a single press. The machine is suitable for pressed ware in block or open and shut molds and will make tumblers, jellies, nappies, tableware and many other items ranging in size from a whiskey glass to a meat platter.

The pressing mechanism is air operated and equipped with the Tandem type of pressing cylinder. Lynch points out that this type of pressing mechanism is a distinct improvement over the single cylinder type from the standpoint of increased flexibility and pressure.

Another interesting feature is that the gear box is provided with a synchronizing mechanism. This makes it possible to stop the machine at any time, while the feeder and motor continue to operate. The advantage of this is that, after the machine is stopped, the feeder will continue to deliver the glass gobs without losing the shape or temperature. It also provides immediate synchronization of press with feeder, when starting up again.

The MPLS press can be used equally well with an air or mechanical feeding device.

NEW COMBUSTION SAFEGUARD

The Brown Instrument Co., a division of Minneapolis-Honeywell Regulator Co., Philadelphia, Pa., state that they have just placed on the market a new and materially improved line of Protectoglo equipment. This apparatus includes two separate and distinct types of relays, and a flame sensitive electrode which can also be used as a special spark plug for electric ignition. Any of the standard line of controllers and motor valves may be used to complete this system of combustion safeguard. The company advises that it will gladly supply complete information on this new system which can be supplied for practically any type of burner equipment.

LINK-BELT'S NEW PRESIDENT

At the annual meeting of shareholders held at the Stevens Hotel, Chicago, Alfred Kauffmann was elected president of the Link-Belt Co., succeeding George P. Torrence. Mr. Kauffmann started with the company 35 years ago as draftsman, and has served as designing engineer, superintendent of construction, sales engineer, vice-president and manager of the Philadelphia plant, vice-president in charge of Link-Belt Dodge and Ewart plants at Indianapolis and for the past four years, first vice-president in charge of Chicago plant operations. He was president of the company from 1924 to 1932 and has been a director since 1922.

B. A. Gayman, president of the Link-Belt Co. Pacific Division, San Francisco, was elected to the directorate at the same time.

UNTARNISHABLE MIRRORS

Semon Bache & Co., New York, announce that they are producing a new type of front surface and transparent mirror without any protective lacquering on the reflecting surface. These "Evabrite" mirrors are said to neither deteriorate nor discolor and to maintain high reflectivity. The mirrors may be had in sizes not exceeding 24 inches in width and 30 inches in length.

The Glyco Products Co., Inc., New York, N. Y. announce that their new address is 148 Lafayette St., New York.

NEW HIGH VACUUM PUMP

Beach-Russ Co., New York, announce a new two-stage integral type high vacuum pump to meet all high vacuum requirements, as in exhausting neon signs, lamps, radio tubes, vacuum bottles, etc., to within ½ micron. For chemical and kindred processes where there is likelihood of moisture content, as in distillation, evaporation, vacuum filtering, drying, moulding, etc., this pump has been guaranteed to maintain vacuum within one M.M. of absolute. It is tested for a vacuum of 1/10 M.M. of absolute.

For chemical and similar plants, the pump may be equipped with the Beach-Russ water-oil separator which collects and discharges all accumulated water without affecting the vacuum produced.

The two cylinders in this vacuum pump are cast integrally to eliminate the need for connecting piping and fittings. Thus the tendency toward leakage between the first and second stages of vacuum are eliminated and considerable in floor space is saved. It is equipped with automatic lubrication and is said to run quietly. The pump is made for capacities of 8, 15, 30, 55, 100 and 200 cubic feet per minute. The Company advises that larger sizes will be built to meet special requirement.

SPEEDS UP CARTONING

An inexpensive tool for sealing corrugated and fibre shipping containers has been introduced by the Paslode Co., Chicago. The Paslode Stapler performs an operation that is said to have never been done before: namely, the stapling of the flaps of any corrugated or fibre container of the overlapped type. The device has a special "S" anvil construction which permits it to slide along the overlapped flap and drive the staples from end to end in one operation.

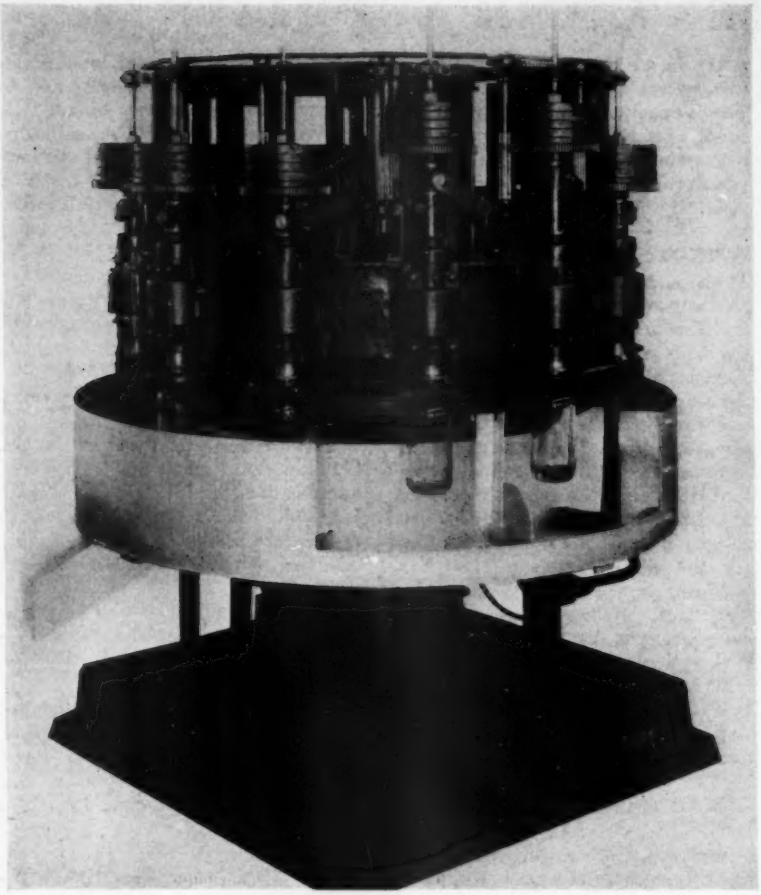
General Refractories Co., Philadelphia, announce the appointment of Braman, Dow & Co., Boston, Mass., as dealer agents in that territory. Braman, Dow & Co., will carry a complete stock of refractories.

Edward Miller, president of the Miller Foundry Co., Columbus, Ohio, upon his recent return from a holiday in Florida, announced the appointment of Calvin P. Wolfe as technical superintendent of the Company. Mr. Wolfe has had extensive experience during the past 25 years in the production of glass moulds and plungers.

Chas. Taylor Sons Co., Cincinnati, manufacturers of P. B. Sillimanite and Fire Clay Refractories, announce the removal of their Eastern District Office to the Hudson Terminal Bldg., 30 Church Street, New York City. Ripley Quinby is the District Sales Manager.

AUTOMATIC PRESSURE TESTING MACHINE FOR BOTTLES

General interest in the subject of testing glassware directs attention to a new pressure testing machine recently delivered to the Glenshaw Glass Co., Glenshaw, Pa. The new testing machine is said to be unlike any previous machine ever built for this purpose. It is automatic in operation and is capable of testing ten siphon bottles per minute, each bottle at a precisely known steady pressure for a full minute period. Previously, it had been the practice for the company to test these bottles for one minute at a pressure some 50 per cent



The bottle testing machine designed by Dr. Preston.

in excess of the highest pressure to be expected in practice. The new machine reduces the time and labor cost of testing and permits the operation to be done without any interruption in the flow of production.

The machine was designed by Dr. Frank W. Preston and was built partly in his shops at Butler and partly at the DuBois (Pa.) Iron Works. It embodies all of the features of Dr. Preston's precision testing machines, described in the November 1934 issue of THE GLASS INDUSTRY, several of which are now in use in the plants and research departments of glass companies both in this country and abroad. In fact the new machine consists essentially of 12 of these individual machines built into a compact unit, with provision made for automatic sealing and application of pressure.

The photograph shows the general appearance of the machine. On a square base, there is mounted a central circular column, around which the whole upper part of the machine revolves. It is driven by a totally enclosed one horse-power gear motor mounted on the base, and controlled by push buttons in front of the operator.

As previously mentioned, there are 12 individual heads, with room for 12 bottles, of which ten are under test at any one time. Of the two bottles in the immediate foreground, the one to the left is ready for removal, and the one to the right has just been placed in position, but has not yet received its load. (For the purposes of photography, the bottles were empty; in practice they are filled with water before being placed in the machine.) The deck rotates counter-clockwise as seen from above, the bottles passing in front of the operator from left to right. The bottles are automatically relieved of pressure just before they reach the operator, and the pressure is not applied till after they have passed from in front of him.

This pressure is applied by a loaded, rotating plunger or spindle, the load being gravitational and known to a fraction of one part in a thousand. The duration of the test is settled entirely by the length of time it takes the machine to make a revolution. The only exception is when the operator stops the machine for any reason, but this cannot *shorten* the test; it can only lengthen it, and no bottle escapes a full test.

In the photograph, it will be seen that the spindles in front of the operator are fully raised, the load being carried by a cam track behind the heads, and the bottles carrying none of it. The other ten spindles are fully lowered: in practice, with the bottles full of water, they ride half-lowered, with their weight resting on the water and developing the desired hydrostatic pressure. The pressure can be adjusted to any desired value from 100 lb/sq. in. upwards in steps of 25 lb/sq. in to 300.

The bottles are fed into the machine and removed from it by hand, but the sealing is automatic, as in the application and removal of pressure. Similarly, the release of the sealing is automatic.

The cullet catcher now has two delivery chutes, and a scraper or brush cleans out the broken fragments, if any.

Immediately after installation of the new machine at Glenshaw, the older testing equipment was abandoned and the full load of the siphon production thrown on the automatic machine. Many scores of thousands of bottles have now been tested on it, and it is intended, hereafter, to prove the strength of all siphon bottles, by its rigid and precise test.

The business in automatic regulation previously carried on by H. A. Brassert & Co., in the iron and steel industry and by the American Askania Corporation in other industries, including the glass, has been united under the name of the Askania Regulator Co. The address is 1603 S. Michigan Ave., Chicago.

The dependability of machinery used in any manufacturing operation is based to a large extent on the suitability of the metals chosen for parts subject to impact shock, severe strains, abrasion or corrosion. Enlarging on this subject is a recent publication of the International Nickel Co., New York, entitled "Nickel Alloy Gear Materials and Their Heat Treatment" by J. W. Sands and F. J. Walls.

CATALOGS RECEIVED

Chicago Grinding Wheels. Chicago Wheel & Mfg. Co., 1101 W. Monroe St., Chicago, Ill. A new up-to-the-minute catalog listing price changes, the first since 1923. It is said that the new list values are true reflections of the cost of manufacturing grinding wheels, which have changed somewhat in the past 13 years.

Motorpump for Air Conditioning Service. No. 2200. Ingersoll-Rand Co., 11 Broadway, New York. A six page bulletin describing the Cameron motorpump as used in air conditioning service in systems of several different types.

Motorpumps may be mounted in any position, horizontal, vertical or at an angle.

Hauck Industrial Combustion Data. Hauck Manufacturing Co., 126 Tenth St., Brooklyn, N. Y. A 60-page book which answers many of the questions which present themselves to industrial heating and combustion engineers. It will be of assistance in solving many problems in connection with effective heating economy and improved operation.

Profit Makers. No. 318. Lewis-Shepard Co., Watertown, Mass. Illustrates and describes many standard and special devices for handling products or materials for storing, shipping or handling.

A Quick Lesson in Materials Handling. No. 199. Lewis-Shepard Co., Watertown, Mass. Deals with stackers and portable elevators, both power and hand hoist, for stacking and piling cases, crates, barrels, etc., from floor to ceiling so as to conserve factory and warehouse space.

Instruments from the Executive Viewpoint. Brown Instrument Co., Philadelphia. Many photographs and pointed descriptions tell the parts played by instruments and control devices in modern industrial plants.

It Centers in Pequabuck. Horace R. Whittier Co., Pequabuck, Conn. This brochure graphically describes and illustrates the several steps in porcelain enameling, as well as its various applications.

Hays Combustion Records. RA-346. Hays Corporation, Michigan City, Ind. Covers the Hays Line of combustion meters and should be of interest to engineers. Complete descriptions of the instruments and engineering data on their application are included.

Industrial Finishes. Pittsburgh Plate Glass Co., Pittsburgh, Pa. Discusses the activities of an important department of Pittsburgh Plate which serves industrial users of paints, varnishes, enamels and lacquers. Descriptions of the various laboratory, field testing, creative design and manufacturing facilities are given.

Machinery for Grinding, Mitering, Smoothing Edges of Structural Glass. No. 361. Sommer & Maca Glass Machinery Corporation, 3600 South Oakley Ave., Chicago, Ill. Specifications and photographs of a broad line of machinery for grinding and polishing glass.

Anti-Friction Bearing Units. No. 1520. Link-Belt Co., 307 N. Michigan Ave., Chicago. Beautifully illustrated 40-page catalog of the complete Link-Belt anti-friction bearing unit line. They are available in stream-lined pillow block, hanger, takeup, flanged, duplex and special mountings.

Propellair Circulator Fans. Propellair, Inc., Springfield, Ohio. A circular illustrating a new development in these ventilating fans. Operates at two speeds and is said to be distinguished by the amount of air flow it supplies, its thrifty consumption of current and minimum of noise in operation.

Switchgear Panels for Engine Driven Generators. No. 1700. General Electric Co., Schenectady, N. Y. A folder describing properly equipped panels for isolated or switchboard installations.

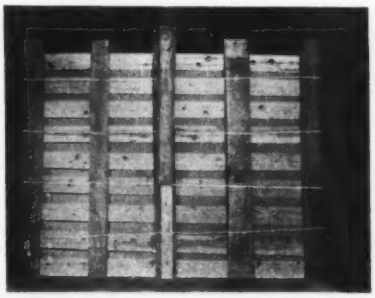
WIRE TYING SAVES MILK BOTTLES IN TRANSIT

The Gerrard Co., Inc., Chicago, who manufacture machinery for wire tying cartons and various heavy containers, have reported a most unusual record in so far as loading glass milk bottles is concerned. In a series of tests conducted at the Thatcher Manufacturing Co., Elmira, N. Y. makers of milk bottles, it is said that the most breakage reported per car was seven bottles, with a total loss of 14 cents. The method of utilizing this so-called "Uni-Lastic" stowage is very interesting.

Both ends of the car are loaded at the same time by two crews of workers. A movable rack on two uprights, as illustrated, supports rolls of thin kraft paper about four inches wide. A strip of this paper is laid on top of each row of bottles, alternating neck and butt so that the nesting is correct. The horizontal board holding the paper rolls can be moved up or down depending on the amount of paper needed. The board is also used for a pressure packing board or aligner to even the rows of bottles. Between each stack of bottles the crew drops a sheet of heavy indented paper to protect each stack from breakage. The paper used is a cheap short fibre pulp paper, similar to blotting paper, which gives a cushioning effect.

Four wires, stapled to car stud posts, are brought and tied in front of the wooden end gates. These gates are constructed of one-by-six lumber, using the hardwood at either end of the gate for uprights where the galvanized high tensile wire comes into direct contact. Incidentally, the greater part of the lumber is salvaged from cars of sand.

The wires are then tensioned with a Gerrard G Model wire tying machine, applying tension evenly to make a snug tie, without being so tight as to crush the bottles. The wires are then tied and automatically cut. The end gates are held down by a center board reaching to the car roof, as illustrated. This prevents the gates from working upward. Upon arrival at their destination, the cars are unloaded by automatic conveyors which take the bottles direct to the washing machines.



Wire tying milk bottles and above, ready for shipment.

and V_{H_2O}

the volumes of the ether layer and water layer, respectively. For routine work where the temperature does not vary more than 2° from 25°C, 0.403 may be used as the value of K without significant sacrifice of accuracy; otherwise its value must be calculated from the equation, $K = 0.673\text{-}0.054\sqrt{t}$ (See Table 3).

The experimental work on this subject was started by J. F. Klekotka, and the authors wish to acknowledge his assistance, and to thank him for the part of the work he did.

9. It became evident during the course of this work that the quality of the ether used in this method must be examined at frequent intervals and should be purified if the *p*-nitrophenol endpoint is not sharp or if the sample, after removal of the ether and ethanol and subsequent acidification, shows color. A satisfactory test method is to treat approximately 50 ml of ether, 5 ml of 0.5 N NaOH, and about 50 ml of distilled water exactly as a sample would be treated for the removal of ether and ethanol. Upon diluting to 35-45 ml and neutralizing with 0.5 N HCl to the *p*-nitrophenol endpoint, no color should be evident. For purification, a modification of the method of Palkin and Watkins[7] was used. The ether was first agitated with asbestos impregnated with alkaline permanganate (5 ml of saturated $KMnO_4$ to 15 ml of 33 per cent NaOH) and then slowly siphoned, in a very fine stream, through a column of the alkaline permanganate into a bottle. This bottle also contained asbestos impregnated with alkaline permanganate and was kept in a cool, dark place.

10. Long standing on the water or steam bath gives a colored acid solution which has a tendency to mask the *p*-nitrophenol endpoint in the final titration.

11. $K = \frac{C_{Et_2O}}{C_{H_2O}}$ or $C_{H_2O} = \frac{C_{Et_2O}}{K}$

$$C_{Et_2O} = \frac{(B_2O_3)_{50Et_2O}}{50} \quad \text{and} \quad C_{H_2O} = \frac{(B_2O_3)_{50Et_2O}}{50\,K}$$

$$(B_2O_3)_{Et_2O} = C_{Et_2O} \times V_{Et_2O} = \frac{(B_2O_3)_{50Et_2O}}{50} \times V_{Et_2O} \qquad (1)$$

$$(B_2O_3)_{H_2O} = C_{H_2O} \times V_{H_2O} = \frac{(B_2O_3)_{50Et_2O}}{50\,K} \times V_{H_2O} \qquad (2)$$

$$\text{The total } B_2O_3 = (1) + (2) = \frac{(B_2O_3)_{50Et_2O}}{50}\left[V_{Et_2O} + \frac{V_{H_2O}}{K}\right]$$

$$\text{Per cent } B_2O_3 = \frac{100 \times B_2O_3}{0.5} = 4(B_2O_3)_{50Et_2O}\left[V_{Et_2O} + \frac{V_{H_2O}}{K}\right]$$

12. Werner Mylius, Chem.-Ztg. 57, 173 (1933).

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